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An assessment of Newfoundland and Labrador Snow Crab (*Chionoecetes opilio*) in 2011

Évaluation du stock de crabes des neiges (*Chionoecetes opilio*) de Terre-Neuve-et-Labrador en 2011

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ABSTRACT

Resource status was evaluated throughout NAFO (Northwest Atlantic Fisheries Organization) Divisions 2HJ3KLNOP4R based on trends in biomass, recruitment, and mortality. Multiple indices of these metrics were derived from a suite of data sources that include dockside-monitored landings, harvester logbooks, at-sea observer monitoring, pre-and post-season trawl surveys, broad-scale post-season trap surveys, localized inshore trap surveys, a vessel monitoring system (VMS), and biological sampling data from multiple sources. The resource was assessed separately for offshore and inshore areas of each NAFO Division, where appropriate (Div. 3KLP4R). Data availability varied among Divisions and between inshore and offshore areas within Divisions. The multi-species trawl surveys indicate that the exploitable biomass has declined since 2009. The trawl surveys indicate that recruitment has recently declined and is expected to decline further in the short term. Longer-term recruitment prospects are unfavourable due to a warming oceanographic regime. Trends in indices are described in detail for each Division and conclusions are presented with respect to the anticipated effects of short-term changes in removal levels on fishery induced mortality.

RÉSUMÉ

L'état du stock de crabes des neiges dans les divisions 2HJ3KLNOP4R de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO) a été évalué en fonction des tendances relatives à la biomasse, au recrutement et à la mortalité. Les indices multiples de ces paramètres proviennent d'une série de sources de données, notamment des débarquements faisant l'objet d'une vérification à quai, des journaux de bord des pêcheurs, de la surveillance en mer effectuée par des observateurs, des relevés au chalut avant et après la saison de pêche, des relevés au casier à grande échelle après la saison de pêche, des relevés au casier localisés dans les eaux côtières, du Système de surveillance des navires et des données d'échantillonnage biologiques tirées de sources multiples. L'état du stock des zones extracôtières et des zones côtières de chaque division de l'OPANO a été évalué séparément, lorsque cela était approprié (division 3KLP4R). La disponibilité des données variait parmi les divisions et entre les zones extracôtières et les zones côtières à l'intérieur des divisions. Les relevés plurispécifiques au chalut montrent que la biomasse exploitable a diminué depuis 2009 et que le recrutement a récemment diminué et qu'il devrait continuer à diminuer à court terme. Les perspectives de recrutement à plus long terme sont pessimistes en raison d'un régime océanographique qui se réchauffe. Les tendances relatives aux indices sont décrites en détail pour chaque division et les conclusions sont présentées par rapport aux effets prévus qu'auraient des changements à court terme dans les niveaux de prélèvement sur la mortalité par la pêche.

INTRODUCTION

This document serves to assess the status of the Snow Crab (*Chionoecetes opilio*) resource surrounding Newfoundland and Labrador (NL) in NAFO Divisions 2HJ3KLNOP4R. The information presented follows from a formal scientific assessment conducted during February 2012, focused upon determining changes in the exploitable biomass of crabs available to the 2012 fishery (commencing in April 2012), as well as to the fisheries of succeeding years.

Snow Crab are sexually dimorphic, with males normally achieving larger sizes than females. Exploitable crabs consist of large males that have not molted within the past 6 to 12 months, as recently-molted animals do not yield commercially acceptable meat content. Production of Snow Crab is largely environmentally driven, with cold temperatures during early life history favouring increased recruitment (Marcello et al., 2012). Growth rates are also affected by temperature, with age-at-recruitment older within a cold regime than within a warm regime due to a lower frequency of molting in cold conditions (Dawe et al., 2012). The minimum legal size is 95 mm carapace width (CW). This regulation excludes females from the fishery and ensures a portion of the adult males remain available for reproduction.

Snow Crab in Newfoundland and Labrador are part of a larger population in Canadian Atlantic waters, ranging from southern Labrador to the Scotian Shelf (Puebla et al., 2008). However, as movements of individuals within the stock are thought to be limited, assessments are conducted at the NAFO Division level (Fig. 1) with inshore and offshore areas considered separately where applicable. This is intended to partially conform with crab management areas (CMAs, Fig. 2) while accommodating different types and amounts of available information.

The NL Snow Crab fishery began in 1967 and was limited to NAFO Div. 3KL until the mid-1980s. It has since expanded throughout Div. 2HJ3KLNOP4R and is prosecuted by several fleet sectors. Management of the increasingly diverse fishery led to the development of many quota-controlled areas with about 3200 licence/permit holders under enterprise allocation in 2011. The fishery is prosecuted using conical baited traps set in long-lines ('fleets'). The minimum legal mesh size is 135 mm to allow small crabs to escape. Under-sized and soft-shelled crabs that are captured in traps are returned to the sea and an unknown proportion of those die.

Data from multi-species bottom trawl surveys, conducted during fall in Div. 2HJ3KLNO, spring in Subdiv. 3Ps, and summer in Div. 4R, are examined to provide information on trends in biomass, recruitment, production, and mortality over the time series. Multi-species survey indices are compared with other relevant indices derived utilizing data from harvester logbooks, at-sea observers, vessel monitoring system (VMS), the dockside monitoring program (DMP), and inshore and offshore trap surveys, toward inferring changes in resource status for 2011 and beyond.

The Snow Crab resource declined during the early 1980s but recovered and remained very large throughout the 1990s. The multi-species trawl surveys indicate that both the exploitable and pre-recruit biomass has declined since 2009 and recruitment is expected to decline further in the short-term. Long-term recruitment prospects are unfavourable due to a warming oceanographic regime.

METHODOLOGY

MULTI-SPECIES TRAWL SURVEY DATA

Data on total catch numbers and weights were derived from multi-species bottom trawl surveys (Fig. 3) conducted during fall in Div. 2HJ3KLNO, spring in Subdiv. 3Ps, and summer in Div. 4R. The trawl used in the spring and fall surveys was changed to a Campelen 1800 shrimp trawl in 1995, and this trawl proved to be more efficient in sampling crabs than the previously used groundfish trawl. The fall post-season trawl survey was conducted annually in all Divisions except Div. 2H, where it was executed during 1996 to 1999, 2004, 2006, 2008, 2010 and 2011. Snow Crab sampling during spring Div. 3LNOPs surveys did not begin until 1999, and data were available from summer trawl surveys conducted in Div. 4R since 2004. The catchability of the survey trawl differs by season; spring (pre-fishery) trawl surveys are considered to be the least reliable because some population components are relatively poorly sampled during spring when mating and molting take place, while the fall trawl surveys are thought to have the highest catchability for Snow Crabs. Prior to 2009, survey abundance and biomass indices were calculated based on a set of common strata that were sampled in all years for each seasonal survey and NAFO Division. Due to gradual attrition of common strata over time, a set of "core strata" was selected in 2009 and used for the assessment since (Fig. 3). This core group included strata most consistently sampled throughout the time series, capturing strata that were common to most years, especially recent years, and does not include inshore strata or deep (>730 m) slope edge strata that have not been regularly sampled. For the summer trawl survey in Div. 4R, all strata occurring within the offshore management area were used to calculate abundance and biomass indices as that survey has suffered less from the attrition of strata over time, although some of the southern strata not considered to represent crab habitat were missed in 2010. The 2004 and 2006 Div. 3L fall surveys, and the 2006 Div. 3NOPs spring survey were incomplete and have been omitted from analyses. In Divisions where both a spring and a fall survey are conducted (Div. 3LNO), only data from fall surveys are used in this assessment.

Snow Crab catches from each survey set were sorted, weighed and counted by sex. Catches were sampled in their entirety or sub-sampled by sex. Sampling of individual crabs of both sexes included determination of carapace width (CW, mm) and (excepting Div. 4R) shell condition. Shell condition was assigned one of four categories: (1) soft-shelled – these crabs had recently molted, have a high water content, and are not retained in the fishery; (2) new-shelled - these crabs had molted in spring of the current year, have a low meat yield throughout most of the fishing season, and are generally not retained in the fishery until fall; (3) intermediate-shelled – these crab last molted in the previous year and are fully recruited to the fishery throughout the current fishing season; (4) old-shelled – these crab have been available to the fishery for at least 2 years. Males that undergo their final (terminal) molt in the spring will remain new-shelled throughout the fishing season of that year and will not be fully hardened until the following year. Therefore, new-shelled legal-sized crabs are not considered to be part of the exploitable biomass, in the current year, although it is recognized that some of these males may be retained by the fishery if it extends late into the season. It is assumed that all males with small chelae molt each spring and so remain new-shelled between molts. In reality, however, an annually variable proportion of small-clawed males will not molt in any given year ('skip molters') and so will develop 'older shells' between molts. For each year that a crab skips a molt, its eventual recruitment is delayed by a year.

Skip-molting is most common in large adolescent males in cold areas (Dawe et al., 2012).

Males were also sampled for chela height (CH, 0.1 mm). Males develop enlarged chelae when they undergo their terminal molt, which may occur at any size larger than about 40 mm CW. Therefore, only males with small chelae will continue to molt and subsequently recruit to the fishery. A model which separates two 'clouds' of chela height on carapace width data was applied (Dawe et al., 1997) to classify each individual as either adult (large-clawed) versus adolescent or juvenile (small-clawed). This model is defined as:

$$CW = 0.0806 CH^{1.1999}$$

Maturity status was determined for females and relative fullness and stage of development of egg clutches were assessed. Occurrence of advanced stages of Bitter Crab Disease (BCD), an assumed to be fatal affliction, was noted in both sexes based on macroscopic examination. In cases of unclear external characteristics, crabs were dissected and classified based on observation of the hemolymph. Observation of cloudy or milky hemolymph supported the classification of such specimens as infected.

We examined annual changes in biomass indices of legal-sized males, by shell condition, toward evaluating the internal consistency of the data series. Males enter the legal-size group as soft-shelled crabs, after the spring molt and remain as new-shelled immediate pre-recruits for the duration of the current year's fishery. They begin to contribute to the legal-sized intermediate-shelled group in the following year. Hence we would expect annual changes in biomass to be first seen in soft or new-shelled legal-sized males and to be followed by similar trends in intermediate, and subsequently old-shelled, males.

Biomass and abundance indices were calculated from spring and fall surveys using STRAP (Smith and Somerton,1981), to represent the exploitable and pre-recruit biomass for males and the abundance of mature females . For spring (pre-season) surveys, these indices represent biomass for the immediately upcoming, or on-going, fishery in the current year whereas for summer and fall (post-season) surveys the indices represent biomass for the fishery in the following year. The exploitable biomass index was calculated as the survey biomass index of adult (large-clawed) legal-sized (>94 mm CW) males, regardless of shell condition. Adult males are terminally molted, so that no members of this category would molt in spring and all adults in the fall survey (including new-shelled adults) would be fully recruited to the fishery in the following year. The exploitable biomass index generated from spring survey data includes a component of new-shelled males that would not actually be retained by the fishery in the immediate or upcoming fishery but would be fully recruited to the fishery in the following year. The offshore exploitable biomass for Div. 4R was calculated based strictly on size, as data on shell condition and chela height are not recorded during these summer trawl surveys. Stations within inshore Div. 4R CMAs and CMA 13 (assessed by DFO Quebec Region) were rejected in calculating biomass indices for offshore Div. 4R.

The pre-recruit biomass index was calculated by applying a 19 mm CW growth increment (Hoenig et al., 1994) to all adolescent (small-clawed) males larger than 75 mm CW caught in the surveys, before applying STRAP. The resultant pre-recruit index, from fall surveys, represents a component of legal-sized (>94 mm CW) males that would be recently-molted, (soft or new-shelled), and not recruited to the fishery of the next year, but would begin to recruit (as older-shelled males) in the following year. However, some of these recently-molted males would have remained adolescent, and so would molt one more time before achieving adulthood and subsequently recruiting to the fishery, as intermediate-shelled males, one additional year later (i.e. 3 years after the fall survey year). The pre-recruit biomass index for Div. 4R was calculated based strictly on size, thus it contains an unknown proportion of sub-legal-sized adult crabs that will never recruit to the fishery. The abundance of mature females was not calculated for the summer trawl survey in Div. 4R due to the unavailability of maturity data from that survey.

The exploitable and pre-recruit biomass indices and the mature female abundance indices were calculated using the raw survey data. It is known that catchability of crabs by the survey trawl (i.e. trawl efficiency) is lower than 1 and varies with substrate type and crab size (Dawe et al., 2010a). However, trends in raw ('unstandardized') indices are comparable to those in 'standardized' indices (Dawe et al., 2003), that partially account for effects of substrate type and crab size. Projection of biomass indices from the survey year does not account for annual variability in natural mortality or in the proportion of skip-molters in the following spring. It is assumed that all small-clawed males molt each year. The spatial distribution of pre-recruit and exploitable biomass was examined using catch rates (numbers per tow) for each survey set.

The ratio of the annual landings to the exploitable biomass index (projected from the fall survey of the previous year) was calculated by NAFO Division to provide an index of exploitation rate. This index overestimates absolute exploitation rate because the survey index underestimates absolute biomass. However, long-term changes in these ratios may be interpreted as reflecting trends in exploitation rate within each Division. It is recognized that annual changes in these ratios may be due to changes in catchability (i.e. trawl efficiency) rather than exploitation rate. However, we feel that long-term trends provide a useful indication of trends in exploitation rates. Inshore commercial catches and data from inshore survey strata in Div. 2HJ3KLNOP were not included in calculating the ratios because inshore survey strata were not surveyed in all years. In Div. 4R, inshore strata have been consistently surveyed in some bays, and the catches from these strata have been removed from offshore indices.

To examine size composition of males, trawl survey catches by carapace width were grouped into 3 mm CW intervals and adjusted to reflect total population abundance indices. In Div. 2HJ3KLNOP, each size interval was partitioned, based on chela allometry, between juveniles plus adolescents (small-clawed) versus adults (large-clawed).

To investigate the possible effect of thermal regime on Snow Crab production or early survival we compared the logbook catch per unit effort (CPUE) indices with lagged (lag of best fit) thermal indices for offshore areas in each of Div. 2J, 3K, 3LNO, and Subdiv. 3Ps. CPUE indices are correlated with exploitable biomass indices from the trawl surveys and provide longer time series. No comparison was conducted for Div. 4R due to the short time series of oceanographic data from surveys. We used two indices of thermal regime, bottom temperature and area of cold bottom water distribution (Snow Crab thermal habitat index). Bottom temperatures used were from shallow strata in each Division (<200 m in Div. 2J, <300 m in Div. 3K and <100 m in Div. 3LNOPs) because settlement of early benthic stages occurs primarily in shallow areas, inshore, and on banks (Dawe and Colbourne, 2002). The thermal habitat index was calculated as the percentage of the area surveyed that was covered by cold water of <2°C in Div. 2J3K, <0°C in Div. 3LNO, and <1°C in Subdiv. 3Ps. Mean bottom temperatures and thermal habitat indices for Div. 2J3K were derived using data from fall surveys, whereas those from Div. 3LNOPs were derived using data from spring surveys.

FISHERY LOGBOOK DATA

Data on commercial catch (kg) and fishing effort (number of trap hauls) were obtained from vessel logbooks. These data were compiled by the Statistics Division, Policy and Economics Branch, Newfoundland Region of Fisheries and Oceans Canada. Catch per unit of effort (CPUE, kg/trap haul) was calculated by year and NAFO Division, and by CMA where applicable. CPUE is used as an index of biomass, but it is unstandardized in that it does not account for variation in fishing practices (eg. soak time and mesh size). Long-term trends in logbook CPUE are presented, as a fishery-based index of trends in biomass, for comparison with other fishery based indices and survey indices.

The number of trap hauls from logbooks was calculated for each Division on a weekly basis to compare the seasonality of the distribution of fishing effort among years, and CPUE was calcuated on a weekly basis to assess fishery performance throughout the season in inshore areas each year. Similarly, weekly CPUEs were compared against the weekly cumulative catch to assess the performance of the fishery against the level of removals in inshore areas each year. Logbook CPUEs were also mapped for 10' x 10' (nautical minutes) cells encompassing the entire fishery distribution each year and used to qualitatively assess area-specific fishery performance within each Division.

The spatial extent of annual fishing effort for inshore and offshore areas of each Division was calculated from commercial logbooks. Sets were assigned to 5' x 5' cells based on logbook co-ordinates. The annual ratio of the total number of cells with fishing effort (≥1 set) to the total number of cells in each area was used as an index of spatial expansion or contraction and compared with trends in fishery CPUE.

OBSERVER CATCH-EFFORT AND AT-SEA SAMPLING DATA

Set and catch data were available from the Observer Program for the same time series as those from the multispecies surveys (1995-2011), but at-sea sampling data have only been collected since 1999. Levels of sampling are generally highest in offshore Div. 3KLNO due to high observer coverage in those areas (Fig. 4). Sampling has been consistently low in inshore crab management areas and virtually absent throughout Div. 2H and 4R. The observer set-and-catch database included details about number of traps, landed catch (kg), and discarded catch (kg) for each set observed. An observer-based CPUE index (kg. landed/trap haul) was calculated from observer data for comparison with inshore and offshore logbook CPUE. This catch rate index was based on set and catch estimates from 1995 to 1998, when no detailed sampling was conducted, whereas it has since been based on detailed sampling of individual crabs.

For offshore areas, where data permitted, a pre-recruit fishing mortality index (PFMI) was developed based on the ratio of the observed catch rate of pre-recruits discarded in the fishery to the preceding trawl survey biomass index of pre-recruits. This index is defined as;

$$PFMI = S\left(\frac{DPI_t}{PBI_{t-1}}\right)$$

where DPI is the catch rate (kg/trap haul) of measured under-sized and soft-shelled pre-recruits (and under-sized adult males) discarded in the fishery, in year t, calculated from observer sampling data. PBI is an index of the biomass of pre-recruits (and undersized adult males) (t x 1000) from the preceding survey; ie. the fall survey of the previous year for Div. 2HJ3KLNO or the spring survey of the same year for Subdiv. 3Ps. S is a scaling factor to account for incomplete and annually variable levels of observer coverage, defined as:

$$S = \frac{Total\ Landings}{Observed\ Landings}$$

The PFMI overestimates pre-recruit mortality because the PBI underestimates pre-recruit biomass, as a result of low catchability of pre-recruits by the survey trawl. However, we feel that long-term trends in this index provide a useful indication of trends in pre-recruit mortality. In both inshore and offshore areas, the percent discarded (by weight) is viewed as an index of wastage in the fishery. It provides an indication of the level of wastage associated with catching and releasing pre-recruits in the fishery, and is not necessarily proportional to the mortality rate on the pre-recruit population.

Data from biological sampling by observers was also used to quantify the catch components, discarded or retained, in the fishery. Entire trap catches of males were sampled for carapace width (mm) and shell condition. Shell condition categories differed slightly from those used for trawl surveys, in that categories of crabs not recently molted (intermediate-shelled and old-shelled in trawl surveys) were pooled into a single category. These biological sampling data were used to identify specific categories of discards (ie ‘undersized’ and ‘soft’ legal-sized). Also, seasonal trends in the percentage of soft-shelled crabs were described. Discarding of recently-molted (especially ‘soft’) immediate pre-recruits is believed to impose a high mortality on those individuals. A soft-shell protocol was implemented in 2004 to close specific small fishing areas when the percentage of soft-shell crab reached 20%. This was reduced to 15% for offshore Div. 3LNO in 2009 and 2010.

VESSEL MONITORING SYSTEM (VMS) AND DOCKSIDE MONITORING PROGRAM (DMP) DATA

Data on hourly offshore vessel positions from VMS, and landed catch from DMP, were obtained from the Fisheries Management Branch and the Policy and Economics Branch, Statistics Division, Newfoundland Region of Fisheries and Oceans Canada. These datasets were merged based on vessel registration number (VRN), year, month, and day. A CPUE index (kg/fishing hr.) was calculated by year and NAFO Division, as described by Mullowney and Dawe (2009). Fishing hours were screened based on location and speed from hourly positional signals. Signals occurring at 0.1 – 3.0 knot speeds were accepted as fishing signals. The VMS dataset consisted of a short (seven-year) time series and was limited to offshore fishing fleets.

VMS-based CPUE is used as an index of biomass, but it is unstandardized in that it does not account for variation in fishing practices (eg. soak time and vessel drift) (Mullowney and Dawe, 2009). Trends in VMS-based CPUE are presented as a fishery-based index of trends in biomass for offshore areas and compared with commercial logbook and observer-based CPUE indices. CPUE was calcuated on a weekly basis to assess fishery performance throughout the season in offshore areas each year. Similarly, weekly CPUEs were compared against the level of cumulative catch to assess the performance of the fishery in relation to the level of removals in offshore areas each year.

INSHORE TRAP AND TRAWL SURVEYS

Data were available from inshore Div. 3K trap surveys that were carried out in White Bay and Notre Dame Bay during 1994-2011. There were no surveys in either bay in 2001, and no survey was conducted in Notre Dame Bay in 2009 or 2011. The survey has consistently occurred in September and occupies 5 of the inshore fall multi-species survey strata (Fig. 5) with a target of 8 sets per stratum. Each set includes 6 traps, with crabs sampled from two large-meshed (commercial, 135 mm) and two small-meshed (27 mm) traps. Catch rate indices (kg/trap haul) of legal-sized males were calculated by shell category (new-shelled recently-molted versus older-shelled), and size distributions were described by claw type (small-clawed juveniles plus adolescents versus large-clawed adults). Mortality was also inferred from levels of BCD observed in these surveys.

Data were also available from two inshore trap and trawl surveys (1979-2011) within Div. 3L (Bonavista and Conception bays) and one within Subdiv. 3Ps (Fortune Bay, 2007-2011) (Fig. 5). These surveys were conducted in different seasons; spring (Fortune Bay – Subdiv. 3Ps), summer (Bonavista Bay – Div. 3L), and fall (Conception Bay – Div. 3L). They utilized traps of various mesh sizes for each set, including two small meshed (27 mm) traps. For each survey series, catch rate indices and size distributions were produced as described above for the inshore Div. 3K trapping surveys, and prevalence of BCD was noted. No survey was conducted in Fortune Bay in 2008, and the trawling portion of the survey in 2009 was omitted from analyses due to gear mis-configuration in that year.

POST-SEASON TRAP SURVEY

Data were examined from industry-DFO Collaborative Post-Season (CPS) trap surveys in Div. 2J3KLOPs4R (Fig. 6). These surveys, funded by the Fisheries Science Collaborative Program (FSCP), were examined for the first time in 2006. They were initiated following the 2003 fishery and conducted annually thereafter, beginning September 1st each year. The surveys, conducted by Snow Crab harvesters accompanied by at-sea observers, focus on commercial fishing grounds within individual CMAs. Survey stations are fixed and generally follow a grid pattern, with maximum station spacing of 5' X 5' (Fig. 6). At each station, 6 (inshore) or 10 (offshore) commercial (135 mm mesh) crab traps are set in a fleet. All crab caught are sexed and counted. Biological sampling of male crab is conducted at-sea, by observers, from one trap at each station. Sampling includes determination of carapace width, shell condition, leg loss, and presence of BCD. Small-mesh traps are included at selected stations to collect information on pre-recruits and females. However, due to temporal and spatial inconsistencies in the distribution of small-mesh traps, indices are not available for all areas in all years.

The CPS trap survey is more spatially limited than the multi-species trawl surveys, as it targets only portions of commercial fishing grounds. For analysis of catch rates (numbers per trap), a set of core stations was selected from the survey (Fig. 6) due to incomplete and spatially variable survey coverage each year. Biomass indices derived from this survey were based on a stratification scheme introduced in the previous assessment (Mullowney et al., 2012a) (Fig. 6). In previous years, the multi-species trawl survey stratification scheme was used to derive biomass estimates from the CPS trap survey (Dawe et al., 2011). However, it was abandoned due to poor and non-random spatial coverage of the stratification template by the CPS survey. The depth-based stratification closely conforms with all stations occupied in inshore and offshore management areas of each Division since 2004. The boundary of each stratum extended 5nm outside the outermost stations of each survey grid. The set of strata used was common to all years for each zone. Exploitable and pre-recruit biomass indices were calculated from trap survey catch rates using STRAP in a fashion similar to it's application to the multi-species survey data, modifying the program with respect to the area-depth stratification scheme and applying an effective area fished of 0.0053 km^2 (Dawe et al., 1993), analagous to the area swept by a single trawl survey tow, to extrapolate trap catch rates across the total survey area.

RESULTS AND DISCUSSION

DIVISION 2HJ3KLNOPS4R

The Fishery

The fishery began in Trinity Bay (CMA 6A, Fig. 2) in 1967. Initially, crabs were taken as gillnet by-catch but within several years there was a directed trap fishery in inshore areas along the northeast coast of Div. 3KL from spring through fall. Until the early 1980s, the fishery was prosecuted by approximately 50 vessels limited to 800 traps each. In 1981, fishing was restricted to the NAFO Division where the licence holder resided. During 1982-1987, there were major declines in the resource in traditional areas of Div. 3K and 3L while new fisheries started in Div. 2J, Subdiv. 3Ps, and offshore Div. 3K. Since the late 1980s, the resource has increased in these areas. Commercial quota allocations for began in Div. 4R in the early 1990s and in Div. 2H in 2008, although there were prior small-scale exploratory fisheries in these areas.

Licences supplemental to groundfishing were issued in Div. 3K and Subdiv. 3Ps in 1985, in Div. 3L in 1987, and in Div. 2J in the early 1990s. Since 1989, there has been a further expansion in the offshore. Temporary permits for inshore vessels <35 feet, introduced in 1995, were converted to licences in 2003 and exploratory licences in the offshore were converted to full-time licences in 2008. There are now several fleet sectors and about 3200 licence holders participating in the fishery, with several rationalization initiatives gradually reducing the number of active licences in recent years. In the late 1980s, quota control was initiated in all management areas (Fig. 1) of each Division. All fleets have designated trap limits, quotas, trip limits, fishing areas within Divisions, and differing seasons. Mandatory use of the electronic vessel monitoring system (VMS) was fully implemented in all offshore fleets in 2004, to ensure compliance with fishing area regulations.

The fishery was traditionally prosecuted during summer and fall but has become earlier in recent years and is now primarily prosecuted during spring and early summer. Late fishing seasons are believed to contribute to a high incidence of soft-shelled immediate pre-recruits in the catch. The fishery can be delayed in northern Divisions (Div. 2HJ and 3K) in due to ice conditions in some years. Such severe ice conditions can affect the spatial distribution of fishing effort and fishery performance. The fishery can also be delayed for other reasons in some years, such as price disputes like the one that occurred in 2010.

Historically, most of the landings have been from Div. 3KLNO. Landings for Div. 2HJ3KLNOP4R (Table 1, Fig. 7) increased steadily from 1989 to peak at 69,100 t in 1999, largely due to expansion of the fishery to offshore areas. They decreased throughout the early 2000s but increased by 22% from 44,000 t in 2005 to 53,500 t in 2009, and since changed little, at 53,000 t in 2011, with an increase in the south (Div. 3LNOPs) and a decline in the north (Div. 2J3K).

Effort, as indicated by estimated trap hauls, approximately tripled throughout the 1990s (Dawe et al., 2004). It declined in 2000 and increased slightly thereafter. Increasing effort in the 1990s was primarily due to vessels <35 feet with temporary seasonal permits entering into the fishery. Effort has been broadly distributed in recent years (Fig. 8), but there has been a reduction along the slope edges in Div. 2J3KOPs since 2003 (Dawe et al., 2004). Effort increased greatly in offshore Div. 3K from 2008 to 2009 (Dawe et al., 2011) and remained high in 2010 and 2011 (Fig. 8). Effort in inshore areas of Div. 4R had become increasingly contracted and highly aggregated throughout the 2000s, but increased in 2011. Another notable change in recent years has been an increase in effort in west-central portion of the Grand Bank (in CMA 8B) since 2008.

Biomass

The fall distribution of exploitable males (legal-sized adults, Fig. 9) as well as immediate pre-recruits (>75 mm adolescents, Fig. 10) throughout Div. 2HJ3KLNO in 2011 was generally similar to the distribution pattern observed throughout 1997 to 2009, as previously described (Dawe et al. 2011, Dawe and Colbourne, 2002) with some exceptions. Large males have consistently been virtually absent over a broad area of the shallow (<100 m) southern Grand Bank throughout the time series. The abundance of largest males (Fig. 9) has decreased in the northernmost areas (Div. 2J3K) since 2007, while increases occurred in the southernmost areas (Div. 3LNO) from 2008 to 2010 but decreased in 2011. Survey catch rates of pre-recruit males (Fig. 10) in 2011 were generally lower throughout the survey area in 2011 compared to 2009 and 2010. Densest aggregations of small adolescent males (<60 mm CW, Fig. 11) occurred in the north (Div. 2J3K) from 2006 to 2008, but a notable shift to southern Divisions (Div. 3LNO) occurred in 2009-2010, while in 2011 catch rates of small males generally decreased throughout the survey area. Similarly, there was a marked decrease in abundance of mature females (Fig. 12) in most areas in 2011 relative to previous years.

Trends in distribution over the 1995-2000 period were reviewed by Dawe et al. (2003) and Dawe and Colbourne (2002). These trends included gradual spatial shifts of highest densities of most size groups, but also sharp annual and area-specific changes in survey catch rates. Such sharp area-specific annual changes in density that occur across both sexes and the entire broad male size range imply spatial and annual variability in catchability by the survey trawl (Dawe and Colbourne, 2002).

The multi-species trawl surveys indicate that the exploitable biomass has declined since 2009 (Fig. 13). The fall post-season surveys contribute most greatly to the overall picture, indicating that in Div. 2J3KLNO the exploitable biomass was highest during 1996 to 1998 with a secondary peak occurring in the late 2000s.

Production

Recruitment: Recruitment has recently declined and is expected to decline further in the short term. The increased survey biomass indices of pre-recruits (Fig. 13) from 2005 to 2009 was primarily due to increases in the south (Div. 3LNOPs). Longer-term recruitment prospects are unfavourable due to a warming oceanographic regime. The Snow Crab thermal habitat index (Fig. 14), reflecting the distribution of favourable cold habitat, beneficial for early survival and subsequent recruitment, has decreased in most Divisions, especially northern Divisions (Div. 2J3KLNO) where the index was near zero in 2011. While a decrease in area of cold water has occurred in Div. 3LNO, in both spring and fall surveys, the degree of warming has been generally lesser in southern areas, especially Subdiv. 3Ps where recent decreases in the coverage of cold water have been least severe (Fig. 14).

Low bottom temperatures promote terminal molt at small sizes in Snow Crab, resulting in relatively low recruitment from a given year class (Dawe et al., 2012). However, recruitment is more strongly affected by the positive effects of a cold regime on year class production

(Marcello et al., 2012) than it is on the negative effects of a cold regime on size-at-terminal molt. Negative relationships between bottom temperature and Snow Crab CPUE have been demonstrated at lags of 6 to 10 years (Dawe et al., 2005, 2008) suggesting that cold conditions early in the life history are associated with the production of strong year classes and subsequent strong recruitment. Temperatures on the Newfoundland Shelf were below normal in most years from the mid-1980s to about 1995. These were years of high crab productivity that led to high commercial catch rates during the 1990s. A warm oceanographic regime has persisted over the past decade (Colbourne et al., 2012) implying poor long-term recruitment prospects.

The fall surveys indicate that there had been a decline in abundance indices of smallest males (<40 mm CW) since the early 2000s that may indicate reduced biomass in the long term (Fig. 15-16). These size frequencies also show the decrease in pre-recruit males (>75 mm CW adolescent) that has occurred since 2009. We feel there is higher uncertainty associated with the pre-recruit index than with the exploitable biomass index. This difference in uncertainty is not due to differences in precision of estimates but is primarily related to differences in molt status between the two groups. The exploitable biomass index is comprised exclusively of males that were terminally-molted adults in the surveys, whereas the pre-recruit index includes a large component of males that were adolescents as small as 76 mm CW during the surveys. The projection of the pre-recruit index assumes that all those adolescents will molt, survive, grow by 19 mm CW, and subsequently recruit over the following two years, involving yet an additional molt for those that remained legal-sized adolescents, as older-shelled males. In reality, the biomass of new-shelled pre-recruit crabs is greatly affected by annual variability in natural mortality, growth increment, and proportions that fail to molt. These variables currently cannot be predicted and so are not accounted for.

Reproduction: The abundance of mature females (Fig. 17) captured during the fall trawl survey was highest in 1995 and declined precipitously to 1998. It varied without trend for most of the 2000s but increased sharply in 2008. It has since declined to its lowest level in 2011. The percentage of mature females carrying full clutches of viable eggs has remained high (ie. exceeding 80%) in most years, including all recent years.

Mortality

Bitter Crab Disease (BCD) has been observed in Snow Crab, based on macroscopic observations, at generally low levels throughout 1996 to 2011. The prevalence and distribution of this parasitic disease throughout the Newfoundland-southern Labrador continental shelf (Div. 2J3KLNO) has been described in detail by Dawe (2002) and appears related to circulation features along the NL shelf (Dawe et al, 2010b) as well as the density of small adolescent crabs (Mullowney et al., 2011). It is thought the disease moderates the strength of recruitment pulses occurring in the population.

There had been a broadly-distributed incidence of bitter crab disease during 1996 to 2006, but the distribution became limited to localized aggregations at low prevalence, primarily in Div. 3K and 3L, in 2007 (Fig. 18). In 2008, BCD prevalence increased in offshore portions of Div. 2J and Div. 3K, but was virtually absent across most of the survey area in 2009. In 2010, there appeared to be a substantial increase in the distribution and prevalence of BCD in offshore Div. 3K. However, this increase has been attributed to technical error and deemed anomalous. BCD was virtually absent across most of the survey area in 2011, likely reflecting a reduced overall abundance of smallest crabs along the NL shelf.

This disease, which is fatal to crabs, primarily occurs in new-shelled crab of both sexes and appears to be acquired during molting (Dawe, 2002). It is unknown how well apparent disease prevalence in trawl-caught samples represents true prevalence in the population, as diagnosis has been based on recognition of external characteristics in chronic cases. However, it seems likely that our observations underestimate true prevalence.

DIVISION 2H

The Fishery

There have been exploratory fisheries in Div. 2H off central Labrador (Fig. 19) since the mid-1990s. A commercial total allowable catch (TAC) of 100 t was first established in 2008 and maintained until it was reduced to 70 t in 2011 (Table 2, Fig. 20). The TAC has not been taken for three consecutive years. Fishery data are very limited due to low rates of logbook returns in most years. Landings declined by 95% from 190 t in 2007 to 10 t in 2011 (Table 2, Fig. 20). Effort was relatively consistent from 2005 to 2009, increased sharply in 2010, and subsequently decreased back to about the 2005-2009 level in 2011 (Fig. 20). CPUE has declined steadily since 2006 (Table 2, Fig. 21) in both the VMS and logbook indices.

Prior to becoming commercial, the exploratory fisheries in Div. 2H had been concentrated along the shelf edge, east of the Makkovik Bank, as it was during 2007 (Fig. 22). However, in 2008 there was a shift with much of the effort occurring west of the Makkovik Bank and closer to shore in the southern portion of the Division. This near-shore area was most commonly fished in 2009, but in 2010 and 2011 the effort was re-distributed throughout the Division. There is a high degree of uncertainty in the distribution of effort in recent years due to the low rates of logbook returns.

The fishery has predominately occurred during June and July since 2007 (Fig. 23). The especially low level of logbook returns in 2010 is reflected in the temporal distribution of recorded fishing effort, with data available from only one week, whereas quota monitoring reports showed the fishery to run from late June to mid-August in 2010. In 2011, the fishery occurred from late June to early August.

Biomass

Neither the logbook nor VMS-based CPUE indices are considered fully reliable due to data deficiencies but are consistent in showing a deterioration of fishery performance since 2006. Fishery catch rates began to deteriorate to the east of the Makkovik Bank in 2007 (Fig. 24). The subsequent emergence of fishing west of the Makkovik Bank yielded high catch rates of 16-20 kg/trap in 2008 but CPUE has since decreased in this area as well. CPUE is currently low throughout the Division.

Weekly catch rates from logbooks are highly variable in this fishery (Fig. 25), but show a tendency to peak near the mid to late portions of the season in some years. However, in 2011 there was very little variability in CPUE as it remained very low, at about 1 kg/trap, throughout the season. Data are inadequate to assess the performance of the fishery in relation to cumulative removals due to the low level of catch in 2011 (Fig. 25).

The exploitable biomass is very low. The post-season trawl survey exploitable biomass index decreased by 94% since the 2006 peak (Table 3, Fig. 26). The majority of exploitable-sized crabs captured in the trawl survey from 2006 to 2010 were taken from the extreme southeast portion of the Division near the slope edge (Fig. 27), but no crabs were captured in this area in 2011.

Production

Recruitment: Recruitment has decreased since 2004 and is expected to be low over the next several years. There were no pre-recruit males captured in the 2010 post-season trawl survey (Table 3, Fig. 28). We examined annual changes in biomass indices of legal-sized males from fall multi-species surveys by shell condition (Fig. 29) toward evaluating the internal consistency of the data series. Males enter the legal-size group, after the spring molt, as soft-shelled crabs and they begin to contribute to the legal intermediate-shelled group in the following year. From 2004 to 2008, new-shelled crabs dominated the legal-sized population component. However, in 2010-2011 the catch was almost wholly intermediate-shelled. This suggests recruitment into the legal-sized component of the population (as new-shelled crabs) has recently decreased.

Size compositions from fall multi-species surveys (Fig. 30) show a clear pattern of modal progression between 2004 and 2006, as adolescent pre-recruits in 2004 recruited as adults to the exploitable biomass by 2006 and subsequently became depleted, with virtually no small crabs evident during 2008-2011. The majority of pre-recruit crabs captured in the trawl survey have been taken from the same general area as the exploitable crabs, to the east of the Makkovik Bank (Fig. 27), with no crabs captured there in the past two years. Therefore, short-term recruitment is expected to be low over the next several years.

Longer-term recruitment prospects are poor. There have been no small males (<60 mm CW) captured in the post-season trawl survey since 2001 (Fig. 30). This could be exacerbated by a general warming trend, consistent with trends in other northern (i.e. Div. 2J3K) Divisions (Fig. 14). In Div. 2H the warming of bottom water has been clearest at shallow (<200m) depths (Fig. 31), where most settlement is thought to occur, and where bottom temperature likely exhibits its greatest influence over early-life survival.

Mortality

Data are insufficient to calculate annual values for the exploitation rate index due to the variable frequency of the survey. A pre-recruit fishing mortality rate index cannot be calculated due to the absence of observer data.

DIVISION 2J

The Fishery

The Div. 2J fishery occurs in offshore regions of southern Labrador (Fig. 32). Landings (Table 4, Fig. 33) peaked in 1999 at 5,400 t, decreased sharply to 3,700 t in 2000 and changed little to 2002, before declining to 2005. They increased by 60% from 1,500 t in 2005 to 2,400 t in 2008 and then decreased by 21% to 1900 t in 2011. Effort (Table 4, Fig. 33) increased from 2000 to a record high level in 2002-2004. It decreased sharply in 2005, declined further to 2008, and subsequently increased by 52% to 2011. Commercial catch rate (CPUE) has oscillated over the time series (Table 4, Fig. 34), initially decreasing from 1991 to 1995, and increasing to a peak in 1998. It declined steadily by 76% from 1998 to a record low level in 2004. It increased to another peak in 2008 and has since decreased by half, based on observer and logbook indices. The increase in VMS CPUE in 2011 was likely due to earlier fishing by large vessels, equipped with VMS, than by smaller vessels.

The 2011 fishery was concentrated in Hawke and Cartwright channels (Fig. 35), as it was in the previous five years. In 2011 there was an emergence of some effort in the extreme north of the Division (Fig. 35), west of the Harrison Bank, outside the normal fishing areas. Since 2007 there has been limited fishing along the shelf edge.

The 2010 and 2011 fisheries began in early May and virtually all effort was expended after about fourteen weeks each year (Fig. 36). Relative to 2007-2009, the 2010 and 2011 fisheries began early. This may be attributable to the relatively limited ice extent off the Labrador Coast during the past two springs.

Biomass

Commercial CPUE has oscillated over the time series and is currently in a decreasing phase (Fig. 34). The commercial logbook, observer, and VMS CPUE indices all decreased from 2008 to 2010, with the divergence in 2011 likely attributable to the large-vessel fleets starting to fish earlier than the small-vessel fleets and capitalizing on initially high catch rates. Such fleet-specific differences can affect the CPUE indices more in this Division than any other, as the entire fishery occurs offshore. VMS is exclusive to large-vessel fishing fleets which are able to access the fishing grounds earlier when factors such as ice can affect the fishery. In other Divisions there is little to no overlap of the grounds fished by the large and small-vessel fleets. Decreases in fishery performance over the past few years have occurred throughout Div. 2J (Fig. 37), with the Cartwright Channel area in the northern portion of the Division performing especially poorly in 2011.

The spatial coverage of the fishery has been inversely related to commercial CPUE (Fig. 38). The percentage of available 5' x 5' cells occupied by the fishery declined abruptly from its highest level of 19% in 2004 to its lowest level of 8% in 2006 and has since gradually increased. The inverse relationship between spatial coverage of the fishery and commercial CPUE likely reflects harvester searching behaviour, with the necessity to search for new or alternate fishing grounds when catch rates are low or in decline. Conversely, when catch rates are high, there would be little need to search for alternate fishing grounds. However, in Div. 2J the annual distribution of ice coverage could also influence the spatial distribution of fishing, such as in 2009, when the spatial index increased sharply during a heavy ice year.

Weekly CPUE trends are normally highest during the initial portion of the season and tend to decline during the first 4 to 5 weeks of fishing each year (Fig. 39). Catch rates tend to remain low for the duration of the season, although they can increase slightly during the latter portions of the fishery in some years. In 2011, CPUE was at its lowest observed level in recent years throughout the season. In terms of fishery performance versus cumulative removals the 2011 fishery performed very poorly. For example, after just 500 t of catch, the CPUE of about 7 kg/trap was nearly 50% lower than it was at that level of removals in most recent years (Fig. 39).

Size distributions from at-sea sampling by observers (Fig. 40) showed decreasing catch rates of legal-sized males from 1999 to 2004 (Dawe et al., 2010c), reflecting the trend in CPUE. Modal CW increased from about 92 mm in 2004 to 110 mm in 2008 with an overall increase in abundance of legal-sized animals, reflecting an increase in the exploitable biomass as members of a recruitment pulse molted and grew to large sizes. The primary mode remained at 110 mm in 2009, but abundance of most sizes was marginally lower than in 2008. In 2010 and 2011 there was little change in the shape of the size frequencies, but catch rates of all sizes decreased. Furthermore, the catch was dominated by old-shelled crabs during the past two years, indicating little recruitment entering into the exploitable component of the population.

The increased observer catch rate of legal-sized males in 2007-2009 was almost wholly attributable to increases in new-shelled crabs (Fig. 41). The subsequent increased catch rates of old-shelled crabs in 2010-2011 is consistent in showing a recruitment pulse that has now fully entered into the legal-size range.

The exploitable biomass has decreased in recent years. The post-season trawl survey exploitable biomass index decreased steadily by 92%, from 1998 to 2002 (Table 5, Fig. 42). It then increased to peak in 2006 but remained below pre-2002 levels and has since decreased by half. The post-season trap survey index declined sharply from 2007 to 2009 and since increased to 2011. However, that index reflects only the Hawke Channel in the southern portion of the Division. The capture of exploitable crabs by the trawl survey has become increasingly contracted into the Cartwright and Hawke channels in recent years (Fig. 43).

The increase in the fall survey exploitable biomass index from 2002 to 2006, was small relative to the increase in CPUE indices (Fig. 34). This likely reflects effects of recent management changes in the fishery on fishery performance (CPUE) as described earlier.

Production

Recruitment: Recruitment has recently been in decline, as reflected by the decline in exploitable biomass between 2006 and 2009 (Fig. 42) while landings changed little (Fig. 33). The post-season trawl survey pre-recruit index was exceptionally high in 2004, decreased sharply in 2005, and has since fluctuated without trend (Table 5, Fig. 44). The post-season trap survey index, from the southern portion of the Division only (Hawke Channel), has changed little over its limited time series (Fig. 44). The capture of pre-recruit males in the fall trawl survey has been almost exclusive to the Cartwright and Hawke channels (Fig. 45). In these two areas, the catch rates have decreased in the Cartwright Channel during the past two years while catch rates in the Hawke Channel remain similar, or slightly higher, than those from 2006 to 2009.

Males enter the legal-size group as soft-shelled crabs, after the spring molt, and they begin to contribute to the legal intermediate-shelled group in the following year. Trends in the biomass index by shell condition reflect this process, in that the biomass of new-hard-shelled males peaked in 1997-1998 whereas that of intermediate-shelled males peaked in 1998-1999 (Fig. 46). The biomass index of new-hard-shelled males dropped sharply in 1999, whereas biomass of intermediate-shelled crabs declined steadily during 2000-2002. The biomass of new-hard-shelled crabs increased steadily from 2002 to 2006 while the biomass of older-shelled crabs remained low. This suggests that the fishery has been highly dependent upon immediate recruitment, which has been gradually declining since 2006. Shell condition-specific catch rates of legal-sized males from the CPS trap survey in the Hawke Channel are consistent in showing the decline in exploitable biomass from 2007 to 2009 being attributable to a decline in new-shelled males (Fig. 47), with little to no improvement since.

The size compositions from fall multi-species surveys (Fig. 48) are examined with the abundance index (ordinate) truncated for smallest males (<50 mm CW), so as to focus on trends in abundance for larger males. The survey data indicate that most of the relatively abundant sub-legal-sized adolescent males evident in 2004 achieved legal size in 2005-2007, and the abundance of most sizes of legal-sized crabs has since declined. The size distributions (Fig. 48) suggest that abundance indices of smallest males (<50 mm CW) decreased from 2002 to 2004 and have remained low since, with the exception of higher catches during 2007-2009. The modal group of 75-92 mm CW pre-recruits in 2004 that progressed into the exploitable biomass during 2005-2010 may have been derived from the large modal group of smallest (<50 mm CW) males in 2001, but there has been no clear evidence of modal progression over the time series. The size compositions from the post-season trap survey (Fig. 49) show a decrease in catch rate throughout most of the size range of sub-legal and legal-sized crabs from 2007 to 2009, most prominent in new-shelled males, but slight increases in catch rates of most sizes in the past two years.

The catch rates of total discards decreased substantially between 2004 and 2006 and have since varied without trend (Fig. 50). However, they were at a recent high during 2011. The recent variability largely reflects trends in the catch rate of soft-shelled legal-sized crabs, which have varied between 0-1 kg/trap since 2005. The catch rates of under-sized crabs have decreased in the past two years, following a high period from 2007 to 2009. High catch rates of soft-shelled crabs in the fishery from 2002 to 2005 did not agree with low catch rates in the post-season trawl survey during 2002-2005 (Fig. 46), implying high handling mortality in those years. However, low observed fishery catch rates of soft-shelled crabs in recent years do agree with low catch rates of new hard-shelled crabs observed in both the post-season trawl (Fig. 46) and trap (Fig. 47) surveys.

The ocean climate indices imply some possible improvement in recruitment in the near future (around 2012 to 2015), due to a relatively cold ocean climate regime 6 years earlier during 2006-2009 (Fig. 51), that is inconsistent with the trawl survey indices (Fig. 44). Such an improvement would be consistent with the increased catch rates of smallest carbs in the trawl survey in 2007-2009 (Fig. 48), when the cold years occurred. However, long-term recruitment prospects are unfavourable due to a warming oceanographic regime. The overall trend is of a warming regime, with record warm conditions in 2010 and 2011.

Reproduction: The percentage of mature females carrying full clutches of viable eggs (Fig. 52) has varied over the time series, but consistently remained above 75%, including in the five most recent years. It is unknown to what extent changes in fecundity affect subsequent abundance of settling megalopae. The number of mature females captured in the trawl survey has been low since 2005, reaching a historical low in 2011.

Mortality

Exploitation: The exploitation rate index declined from 2003 to 2007 and then increased to 2010. However, it has changed little in the past three years (Fig. 53). Maintaining the current level of fishery removals would likely increase the exploitation rate in 2012.

Indirect fishing mortality: The pre-recruit fishing mortality index declined sharply from 2003 to 2005, remained low in recent years, but increased to its highest level since 2004 in 2011 (Fig. 53). The percentage of the total catch discarded (Fig. 53) increased from 2001 to a record high level in 2004. It then declined sharply to 2006, implying reduced wastage of under-sized and new-shelled pre-recruits in the fishery. It has since increased to 2011, due to an increase in the incidence of soft-shelled crabs (Fig. 50), but remains lower than during 2002-2005 (Fig. 53).

Snow Crabs that are caught and released as under-sized or legal-sized soft-shelled males in the fishery are subject to multiple stresses and have unknown survival rates. Time out of water, air temperature, water temperature, and shell hardness all influence the mortality level on discarded Snow Crab (Miller, 1977). Other environmental factors such as wind speed, sunlight and size of the crab may also influence survivability

(Dufour et al., 1997). Poor handling practices such as prolonged exposure on deck and dropping or throwing crab induces limb loss and also leads to increased mortality levels associated with catching and discarding crabs. Recently-molted (soft-shelled) Snow Crab are subject to more damage and mortality than hard-shelled crab (Miller, 1977, Dufour et al., 1997). The increase in the level of soft-shelled discards in the fishery since 2008 (Fig. 50) implies increased wastage of immediate pre-recruit crabs in fishery. The catch rate of soft-shelled crabs increased in 2011 to its highest value since 2005. This is reflected in elevated values of soft-shell prevalence in most weeks of the fishery in 2011 (Fig. 54), especially during the mid-portions of the season when the twenty percent closure threshold was exceeded in two consecutive weeks.

An area of Hawke Channel has been closed to all fisheries except Snow Crab from 2003 to 2012 ("Hawke Box" - Fig. 32). CPUE has trended similarly inside and outside the closed area since its inception (Fig. 55). This implies that other fisheries that do not target Snow Crab do not represent a major source of Snow Crab mortality. A recent study on the effectiveness of this closed area concluded that the Hawke Box has failed to protect pre-recruit crabs largely due to an intensification of the crab fishery inside of it in the years surrounding closure. There were high discard rates of soft-shell crab, at 50-75% of the catch, during 2002-2004 leading to a long-term reduction in Snow Crab productivity in the Hawke Channel (Mullowney et al., 2012b).

Natural Mortality (BCD): BCD occurs almost exclusively in recently-molted crabs (Dawe, 2002, Mullowney et al 2011). BCD in Div. 2J males (Fig. 56) has been most prevalent in small new-shelled crabs of 40-59 mm CW. Prevalence, in new-shelled crabs, has generally been low in this area, usually about 2-3 percent occurrence for that size range, excepting 1999 and 2008, when 18% and 16% of new-shelled adolescents in that size group were visibly infected. BCD had been virtually absent from Div. 2J from 2006 to 2010 and no BCD was detected in 2011. Such low incidence of this density-dependent disease (Mullowney et al., 2011) is consistent with the recent decline in long-term recruitment potential in this Division due to the recently warming oceanographic regime.

DIVISION 3K OFFSHORE

The Fishery

The Div. 3K offshore fishery occurs off the northeast coast of Newfoundland, predominately concentrating between near-shore shallow regions and the Funk Island Bank (Fig. 57). Landings first peaked in 1999 at 17,900 t (Table 6, Fig. 58). They decreased to about 13,000 t in 2000-2004, due to a reduction in the TAC. They decreased sharply in 2005 when the TAC was not fully subscribed because the fishery was closed prematurely due to high levels of soft-shelled crabs in the catch. Landings more than doubled from 6,000 t in 2005 to peak at 12,600 t in 2009 but decreased by 35% to 8,200 t in 2011. The TAC was not achieved in the past two years. Effort decreased sharply in 2005 and changed little until it increased by 71% in 2009 before decreasing by 15% in 2010 and increasing marginally in 2011 (Table 6, Fig. 58). Commercial CPUE (Table 6, Fig. 59) indicates substantial deterioration of fishery performance in recent years. CPUE indices increased sharply from 2005 to record high levels in 2007 (VMS index) or 2008 (logbook and observer indices). All three indices agree that CPUE has declined sharply since 2008.

There have been notable changes in the distribution of the Div. 3K offshore fishery in the past three years (Fig. 60). The effort has intensified throughout the offshore, with the most distinctive increases occurring in the northwest portion of the Division, in and around the St. Anthony Basin, and throughout the Funk Island Deep in the central portion of the Division. The broad-scale distribution of effort during the past three years may be partly due to ice during the early season, especially in 2009, and to application of the soft-shelled protocol each year, which alters the spatial distribution of effort and can adversely affected fishery performance. These factors may have also contributed to an extension to depths greater than those usually fished, such as the mid portions of the Funk Island Deep, during the past three seasons.

The temporal distribution of the 2011 fishery was early relative to the previous four seasons (Fig. 61). The fishery began in early April with most effort expended by the beginning of July.

Biomass

The deterioration of fishery performance over the past two years has occurred throughout Div. 3K offshore (Fig. 62). However, the greatest decreases have occurred in and around the Funk Island Deep, extending along the western portion of the Funk Island Bank. The spatial coverage of the fishery has been inversely related to commercial CPUE since 1995 (Fig. 63). The percentage of available 5' x 5' cells occupied by the fishery increased abruptly in 2009, exceeding 40% for the first time since 2004, and was virtually unchanged at a high level in 2010-2011 while CPUE has been in decline.

VMS-based CPUE was lower throughout the season in 2011 than during the previous four years (Fig. 64). Initial CPUE in 2011 was similar to 2010 but catch rates deteriorated faster and there was no recovery at any point in the season. When compared against cumulative removals, it is evident that the greatest decreases in CPUE occurred after about 4,000 t of crab had been caught (Fig. 64).

Size distributions from at-sea sampling by observers (Fig. 65) show that modal CW has not changed since 2005. Successive annual decreases across the entire size range of legal-sized crabs have occurred since 2008, with the single biggest annual change occurring from 2010 to 2011 (Fig. 65). This depletion has occurred in both the new-shelled and old-shelled components of the exploitable biomass. The observed catch rates of legal-sized old-shelled crabs began to decline in 2008 while the decline in new-shelled crabs began in 2009 (Fig. 66). Both components reached recent lows in 2011, and the overall catch rate of measured retainable crabs was at its lowest observed level.

The exploitable biomass, as indicated by the post-season trap and trawl survey indices, declined by more than half since 2008 (Table 7, Fig. 67). The post-season trawl survey exploitable biomass index decreased from its highest level in the late 1990's to its lowest in 2003, before increasing to 2007. The post-season trap survey exploitable biomass index increased in 2006 (Fig. 67). Both indices remained high to 2008 and declined steadily, by about 60%, to 2011. The pattern of distribution of exploitable crabs captured in the trawl survey was relatively consistent from 2009 to 2010 but was contracted to western and southern portions of the Division in 2011 (Fig. 68).

Production

Recruitment: Recruitment decreased in 2011 and is expected to decrease further in 2012. Prospects remain poor in the short term. Post-season pre-recruit biomass indices from both trap and trawl surveys have decreased by about 40% since 2008 (Table 7, Fig. 69). The recent decrease in recruitment was likely exacerbated by a high handling mortality on soft-shelled immediate pre-recruits in the fishery during recent years. Similar to exploitable crabs, recent decreases in pre-recruit crabs captured in the fall trawl survey have occurred throughout the offshore, but the capture locations of pre-recruit crabs were contracted to western and southern areas in 2011 (Fig. 70).

The recent decrease in recruitment is reflected in the large decrease in biomass of new-shelled legal-sized crabs (Fig. 71), with an especially sharp decrease in 2009 likely reflecting a large handling mortality effect in the 2009 fishery. This index of recently recruited crabs was at a historical low in 2011. Similarly, catch rates of new-shelled legal-sized crabs in the CPS survey have declined in recent years, reaching a historical low in 2011 (Fig. 72).

Size frequencies from the post-season trawl survey (Fig. 73) show a clear decrease across the entire size range of crabs since 2008. Similarly, size frequencies from the CPS trap survey (Fig. 74) show a clear decrease across the entire size range of crabs captured. Size frequencies from small mesh traps in the CPS survey (Fig. 75) show no evidence of progression of small adolescent males through the population since 2006 and also showed the clear effect of declining catch rates across all sizes during 2009-2010. However, catch rates of most sizes of crabs increased in 2011 disagreeing with most other pieces of information that indicate a decrease in exploitable, pre-recruit, and smaller-sized crabs in 2011, which could be a function of the limited spatial distribution of these traps.

The observed catch rate of under-sized crabs in the fishery has changed little since at-sea sampling began in 1999 (Fig. 76), remaining about 1 kg/trap each year. Soft-shell crab discards have shown more variability. Lowest soft-shelled incidence during 2006-2008 was associated with the high exploitable biomass in those years, and the 2009 minor peak in soft-shell discards was associated with the abrupt decline in new-shelled legal-sized crabs in the fall trawl survey (Fig. 71), implying a high handling mortality in the fishery in that year.

The ocean climate indices imply some possible improvement in recruitment in the near future (around 2012-2015), due to a relatively cold ocean climate regime 6 years earlier during 2006-2009 (Fig. 77), that is inconsistent with the survey indices (Fig. 69). However, long-term recruitment prospects are unfavourable, due to a warming oceanographic regime. The overall trend is of a warming regime, with record warm conditions in 2011 (Fig. 77).

Reproduction: The percentage of mature females carrying full clutches of viable eggs (Fig. 78) has exceeded 75% in most years and been close to 100% in the past two years. However, the survey catch of mature females has decreased in recent years (Fig. 78). With the exception of a big spike in 2008, there has been a trend of a gradual decline in catch of mature females since 2004, reaching a recent low in 2011.

Mortality

Exploitation: The trawl survey-based exploitation rate index (Fig. 79) declined sharply between 2006 and 2008 and has since increased back to the 2006 level. Maintaining the current level of fishery removals would likely result in an increase in the exploitation rate and high mortality on soft-shelled immediate pre-recruits in 2012.

Indirect fishing mortality: The pre-recruit fishing mortality rate index (Fig. 79) increased from 2007 to 2011. The percentage of the total catch discarded (Fig. 79) increased from 2001 to a record high level in 2004. It then declined sharply to 2006, implying reduced wastage of under-sized and new-shelled pre-recruits in the fishery. It has since increased to 2011, but remains lower than during 2002-2005. The recent increases in percent discarded likely reflect the generally high levels of soft-shell crabs encountered for long stretches of the fishery in recent years (Fig. 80). There is a general trend for soft shell occurrences to increase with time, and by about weeks 10-13 (ie. mid to late June) levels regularly meet or exceed the twenty percent threshold for grid closures. The continuation of the fishery into weeks 15-17 during these years implies a prolonged period of a month or more of fishing on high levels of soft-shell crab in the fishery in recent years.

A portion of the Funk Island Deep in the south of Div. 3K offshore (Fig. 57) was closed to gillnet fisheries in 2002 and has been closed to all fisheries except Snow Crab during 2005-2011. CPUE increased both inside and outside of the closed area from 2005 to 2008, before decreasing in 2009-2011 (Fig. 81). The decrease in CPUE in 2009 was particularly substantial inside the closed area, which is likely related to the large increase in Snow Crab fishing effort inside the exclusion area (Fig. 53). It appears that high levels of exploitation by the crab fishery have not allowed this closure area to be effective in protecting pre-recruit crabs, as was also the case for the Hawke Box closure area in Div. 2J (Mullowney et al., 2012). This implies that the levels of pre-recruit mortality imposed by other fisheries are of little concern relative to the levels imposed by the crab fishery itself.

Natural Mortality (BCD): Prevalence of BCD, from multi-species trawl samples (Fig. 82), has been higher in this Division than in any other Division, with maximum levels during 1996-1998, and 2008, in the order of 8% in 40-75 mm CW new-shelled males. The high 2010 values have been deemed anomalous due to technician error. Annual trends in BCD prevalence (across all sizes) were similar to those in the survey biomass indices, especially for pre-recruits (Fig. 69), featuring highest values in 1996-1998, a sharp drop to minimum levels in 1999, generally lower levels during 2000-2007, and an increase in 2008. This is consistent with a density-dependent effect on prevalence (Mullowney et al., 2011). The lower prevalence levels in recent years are consistent with the reduced long-term recruitment prospects induced by the warming oceanographic regime (Fig. 77).

DIVISION 3K INSHORE

The Fishery

The Div. 3K inshore fishery predominately occurs in coastal CMAs (3A, 3B, 3C, 3BC, 3D) along the northeast coast of Newfoundland (Fig. 57). Some of the management areas constitute bays (ie. 3B = White Bay, 3C = Green Bay), while the others extend into mid-shore regions. Inshore landings (Table 6, Fig. 83) first peaked in 1999 at 3,500 t and decreased sharply in 2000 due to a TAC reduction. They increased to 3,300 t in 2003, changed little in 2004, and decreased by 21% in 2005. They increased from 2,700 t in 2005 to 3,600 t in 2009, but decreased by 31% to 2,500 t in 2011. The TAC was not taken in three of the five management areas in 2011. Effort (Table 6, Fig. 83) declined from 2004 to 2008 and has since increased by 64%. Commercial CPUE (Table 6, Fig 84) indicates substantial deterioration of fishery performance over the past three years.

With limited room for spatial expansion in most CMAs, the fishing pattern has remained relatively consistent in recent years (Fig. 85). However, there have been some subtle changes including an expansion of effort in Green and Notre Dame bays (CMAs 3C and 3D) in the past three years, particularly in the northern portions of each, and the emergence of increased effort in the extreme northern portion of CMA 3A in 2010-2011 (Fig. 85). The temporal distribution of the fishery has been variable in recent years, featuring an unusually late season in 2009, and a relatively early season in 2011 (Fig. 86). Most effort in 2011 was expended from about mid-April to the end of June.

Biomass

CPUE increased sharply from 2005 to a record high level in 2008, but has since declined by more than half (Table 6, Fig. 84). A high level of bias created by spatiotemporal inconsistency in the distribution of observer coverage among CMAs (Fig. 87) creates uncertainty in observer-based CPUE at the Divisional level and does not allow for interpretation of observer CPUE in some CMAs (Fig. 88). In recent years, CMA 3C (Green Bay) has received consistent high levels of observer coverage, whereas the other CMAs have been more annually variable (Fig. 87). In 2011, CMA 3D (Notre Dame Bay) received its highest ever level of observer coverage, following three years of low coverage, while CMA 3B (White Bay) received no observer coverage. Logbook CPUE for 4 of the 5 CMAs (Fig. 88) showed a trend similar to the overall inshore composite (Fig 84) with CPUE declining sharply since 2008. Only White Bay was an exception, where the fishery was closed in 2010 with the TAC not fully subscribed, contributing to improved fishery performance in 2011.

The spatial coverage of the fishery has been inversely related to commercial CPUE from 1996 to 2011 (Fig. 89). The area fished decreased from about 40-45% of available cells in 2004-2005, to about 30% of cells occupied during 2006-2008. In recent years, the areal extent of the fishery has been increasing, with about 40% of the grounds occupied in 2011. This recent increase in spatial coverage has been opposed by a rapid decrease in CPUE.

CPUE indices show a pattern of depletion throughout the season in all recent years (Fig. 90). Trends in weekly commercial CPUE indicated that the fishery performed more poorly throughout the season in 2011 than it did in 2008-2010 (Fig. 90). Trends in CPUE in relation to cumulative catch (Fig. 90) showed that initial CPUE in 2011 was comparable to that of recent years, but decreased more quickly, and at about 300 t of removals had fully diverged from the better performing fisheries of recent years. As in 2010, after about 1,200 t of removals CPUE remained below 5 kg/trap for the duration of the 2011 season.

The exploitable biomass, as indicated by the post-season trap survey index (Fig. 91), decreased gradually between 2007 and 2010 and since changed little but there is considerable variability among management areas. In the previous assessment (Mullowney et al., 2012a), the low 2009 index was deemed anomalous due to low capture efficiency of traps in some areas during the 2009 survey, particularly in White Bay (CMA 3B). However, upon re-examination of the data in the present assessment it was determined the 2009 White Bay survey was consistent with subsequent events that occurred in the fishery. For example, the sharp decline of CPUE in 2010 and subsequent recovery in 2011 in White Bay (CMA 3B, Fig. 88) is consistent with the exploitable biomass trend with a one year lag in the relationship (i.e. fall survey in 2009 followed by spring fishery in 2010). Accordingly, greater confidence is now afforded to the 2009 point in the exploitable biomass index. However, the 2011 survey point is questionable due to unusually long soak times and poor trap performance in some CMAs, with White Bay again creating the most uncertainty.

Production

Recruitment: While uncertain, recruitment prospects appear to have changed little and there is considerable variability among management areas. The CPS pre-recruit biomass index of undersized crabs (Fig. 92) has varied without trend throughout the time series. The CPS trap survey catch rates of new-shelled legal-sized males, constituting immediate recruitment for the fishery, has changed little since 2004, remaining at about 10 crabs per trap (Fig. 93). Size frequency distributions from the CPS trap survey (Fig. 94) have shown little change in the abundance or shell composition of sub-legal-sized crabs since 2004, with the exception of generally increased catch rates in 2010. Longer-term recruitment prospects are uncertain.

Mortality

Exploitation: The trap survey-based exploitation rate index increased sharply in 2010 and then returned to the 2007–2009 level in 2011 (Fig. 91). Maintaining the current level of removals would likely have little effect on the exploitation rate in 2012. However, it would likely result in increased wastage of soft-shelled immediate pre-recruits in some management areas in 2012.

Indirect fishing mortality: Spatiotemporal inconsistencies in the distribution of observer coverage do not allow for a reliable index of discards at the Divisional level. Data are insufficient to estimate the pre-recruit fishing mortality rate index.

Natural Mortality (BCD): BCD prevalence has been monitored by DFO trap surveys in White Bay and Notre Dame Bay (Fig. 95-98) since 1994. BCD has consistently occurred at much higher prevalence levels in these inshore Div. 3K trap survey samples than in the predominately offshore Div. 3K Campelen trawl survey samples (Fig. 82). This likely reflects differences in catchability of diseased animals between traps and trawls (based on comparative trap/trawl sampling), but it may also in part reflect higher prevalence in inshore than offshore areas. In White Bay, prevalence has been periodic, with two distinct pulses of infection over the time series (Fig. 95). Peaks in prevalence have occurred in successively deeper strata at one to two year time lags. BCD prevalence patterns in White Bay are thought to reflect the relative abundance of small to mid-sized adolescents, and the time lag effect across strata likely reflects an ontogenetic movement of crabs to deeper waters over time (Mullowney et al., 2011). In 2009-2011, BCD prevalence in all three White Bay strata was low, likely indicating that a recent pulse of adolescents has now progressed through the most susceptible size range. This is also apparent on a size-specific analysis for adolescents and adults, with all groups of crabs showing low BCD prevalence in all strata in 2009-2011 (Fig. 96). In Notre Dame Bay, there have been two pulses of infection as well (Fig. 97), but no clear difference in timing between strata as in White Bay. Prevalence originally peaked in 1996, and most recently in 2004-2006. Interestingly, from 2006 to 2008, prevalence was highest in large adolescents in shallow stratum 611, as opposed to smaller adolescents in deeper stratum 610 (Fig. 98). The whole of Notre Dame Bay was not surveyed in 2009 and deep stratum 610 was missed in 2011 due to inclement weather. It is not yet clear if the increased prevalence of BCD in shallow stratum 611 in 2011 reflects the emergence of another recruitment pulse of crabs approaching legal size.

Spatial Variability: Trends by CMA

CMA 3A (Canada Bay): In the north, in CMA 3A (Fig. 57), CPUE recently peaked at a historical high in 2008 before declining sharply to 2010 (Fig. 88) and changed little in 2011. This is consistent with CPUE trends throughout most of the inshore (Fig. 84) of Div. 3K.

CMA 3B (White Bay): Commercial CPUE has been sporadic in recent years, with a sharp decrease in 2010 followed by an equally sharp increase in 2011, with catch rates returning to about the recent norm level of 10-12 kg/trap (Fig. 88). This trend in fishery performance mirrored catch rates of new-shelled and old-shelled crabs in the CPS trap survey (Fig. 99), at a one year lag, with a sharp decrease in 2009 followed by a sharp increase in 2010. If the pattern holds, the subsequent sharp decrease in 2011 (Fig. 99) would indicate another forthcoming decline in CPUE in 2012, but these results are felt to be unreliable due to unusually long soak times and a high number of disturbed traps in the 2011 survey resulting from abnormally windy conditions. The DFO fall trap survey (Fig. 100) in deep commercial strata 614 and 613 was consistent with the CPS survey in showing the sharp decrease in 2009 and subsequent increases in 2010. However, it showed additional increases in catch rates in 2011. This infers improved fishery prospects for 2012. The disagreement between the two surveys in the fall of 2011 creates uncertainty about the 2012 fishery. Size frequency distributions from large-mesh traps in the CPS survey (Fig. 101) reflect the decreased catch rates across the entire size range of crabs in 2011 while small-mesh trap size frequencies from the DFO survey (Fig. 102) reflect increased catch rates of most sizes of crabs. There appears to be a mode of adolescent males, centered at about 83 mm CW in stratum 614 and 613, approaching legal-size which should continue to fuel recruitment in the short-term. However, the magnitude of this pulse is much lower than the levels observed during 2007-2008 (Fig. 102). As the fishery is highly dependent upon incoming recruitment each year, reflected by the domination of new-shelled crabs in the legal-size group (Fig. 99-100), it will be imperative to maximize yield-per-recruit from this approaching recruitment pulse if the fishery is to maintain its current level of landings. Longer-term recruitment prospects are uncertain, but the decreased levels of BCD in small and intermediate-sized adolescents during the past three years (Fig. 96) could indicate a decline in long-term recruitment potential, especially considering the elevated BCD levels of 2005-2008 likely signified the emergence of the recruitment pulse recently and presently contributing to the increasing exploitable biomass.

CMA 3C (Green Bay): There are discrepancies between in-season fishery and post-season survey trends in recent years. Fishery CPUE has oscillated since the late 1980s, and when sufficient, observer CPUE trends have agreed with logbook CPUE trends (Fig. 88). The substantial decrease in CPUE since 2008 appears primarily attributable to the successive depletion of old-shelled legal-sized crabs, with the last peak in new-shelled crabs contributing to the exploitable biomass occurring in 2007 (Fig. 103-104). However, trends in the CPS trap survey indicate an increasing level of new-shelled legal-sized crabs in the population since 2008, and a relatively stable exploitable biomass (Fig. 105-106). Small-mesh traps from the CPS survey consistently show a high proportion of sub-legal-sized adults in the population, with the last strong year of recruitment potential, evident as sub-legal-sized adolescents, occurring in 2006 (Fig. 107). A lower level of recruitment potential since would agree with recent fishery performance and observer sampling trends, but not with large-meshed trap catch rates in the same CPS trap survey. Observer data shows the percentage of the catch discarded has been recently increasing from a low in 2007 (Fig. 108), reflecting diminishing CPUE, as the discard rate of undersized crabs has remained at about 2-3 kg/trap and soft-shelled legal-sized crabs at about 1 kg/trap (Fig. 108). Despite low absolute catch rates of soft-shelled crabs, the weekly percentage of the catch comprised of soft-shelled crabs has been high in recent years, commonly approximating or exceeding the twenty percent closure threshold (Fig. 109). In 2011, soft-shell catches exceeded twenty percent by mid-late April, very early timing for such an occurrence relative to most areas in NL Snow Crab fishery. This implies a low exploitable biomass and a high relative level of fishery-induced mortality on the exploitable population in recent years. Most pieces of information for CMA 3C are coherent in indicating a depleted exploitable biomass with little recruitment occurring in recent years. Reasons for the discrepancies in the large-meshed traps in the CPS survey are unknown. Long-term recruitment prospects are uncertain, but a small mode of adolescents approaching legal-size in small-mesh traps (Fig. 107) could result in marginally improved recruitment prospects over the next several years.

CMA 3D (Notre Dame Bay): Fishery CPUE peaked at a record high level in 2008 before decreasing sharply in 2009 and further since (Fig. 88). Observer sampling showed a marginal increase in catch rates of old-shelled legal-sized crabs in 2010 that followed a peak in new-shelled legal-sized crabs in 2008 (Fig. 110), with both the new-shelled and old-shelled components of the exploitable biomass decreasing across all sizes in 2011 (Fig. 111). Observer sampling generally reflects a precipitous depletion of legal-sized crabs since 2007-2008 (Fig. 111) but the CPS trap survey shows this depletion was halted in 2009, with slight increases in catch rates of legal-sized crabs in the past two years (Fig. 112). Data from the DFO post-season trap survey are insufficient to resolve the apparent discrepancy between observer and CPS trap survey data, as the DFO survey has been incomplete in two of the last three years (Fig. 113). Size frequencies from large-mesh traps in the CPS survey show an increase across the entire spectrum of legal-sized crabs in the past two years (Fig. 114), while small-meshed trap size frequencies from stratum 611 in the DFO survey (Fig. 115) captured virtually no legal-sized crabs in 2011 (Fig. 115). However, this stratum is shallow relative to the majority of the deeper fishing grounds, where most fishing occurs and where the CPS survey focuses. Relative levels of fishery-induced mortality have increased during the past two years as the percentage of the catch discarded has increased (Fig. 116). However, the absolute catch rate of both under-sized and soft-shelled discards remains at a low level, of about 1 kg/trap (Fig. 116). Thus, the increased weekly percentages of soft-shelled crab in the fishery in the past two years, particularly in 2011 when twenty percent was approached or exceeded for much of the season, reflect low overall catch rates in the fishery (Fig. 117). In the short-term, recruitment prospects should change little, consistent with observer discards of undersized and soft-shelled crabs (Fig. 116) and catch rates of new-shelled legal-sized crabs in the CPS survey (Fig. 112), but longer-term prospects are uncertain.

CMA 3BC: Commercial CPUE has been highly variable since 1990 (Fig. 88). CPUE was at its highest in 2008, decreased by half in 2009, and changed little since. This is consistent with trends in overall catch rates of legal-size crabs from the CPS survey, which have been stable in the past three years following a decline from 2006 to 2009 (Fig. 118). Recruitment will likely decrease in 2012, as reflected by a decrease in catch rates of new-shelled legal-sized crabs in the 2011 CPS survey (Fig. 118), with virtually all legal and sub-legal-sized crabs captured being old-shelled (Fig. 119). Long-term recruitment prospects are uncertain.

DIVISION 3LNO OFFSHORE

The Fishery

The Div. 3LNO offshore fishery occurs on and surrounding the Grand Bank off Newfoundland's southeast coast (Fig. 120). Landings, mostly taken in Div. 3L, decreased from 24,500 t in 2007 to 22,000 t in 2009 but since increased to 26,000 t (Table 8, Fig. 121). Effort increased slightly in 2011 following a 2008-2010 decrease (Table 8, Fig. 121). Commercial CPUE (Table 8, Fig. 122) indicates that fishery performance has recently improved. VMS-based CPUE declined to its lowest level in 2008, but has since increased to the long-term average.

Since 2007, most of the effort has been expended across the northern face of the Grand Bank and along the Div. 3N slope edge (Fig. 123). There have been some minor changes in the distribution of fishing in recent years, such as a reduction in effort in the extreme northern portion of the Division along the Div. 3KL line, the emergence of a pocket of effort in the centre portion of the Grand Bank to the northeast of the Whale Deep, and an increase in effort inside of the Whale Deep area of Div. 3O. The 2011 fishery started early relative to the previous four years, beginning in mid-April with most effort expended by mid-August (Fig. 124).

Biomass

In 2010, notable increases in CPUE occurred across most of the northern Grand Bank and along the Div. 3N slope while declines occurred in the Whale Deep (Fig. 125). In 2011, the outer portions of the Grand Bank experienced decreases in CPUE, as did the Whale Deep and Haddock Channel areas on the western part of the Grand Bank (Fig. 125). Meanwhile, the Div. 3N slope fishery experienced further increases in CPUE in 2011. The spatial coverage of the fishery has been inversely related to commercial CPUE since 1999 (Fig. 126). The percentage of available 5' x 5' cells occupied by the fishery increased from 2006 to 2009 as CPUE declined. The sharp increase in CPUE in 2010 was opposed by a sharp decrease in areal extent of the fishery, and both indices were unchanged in 2011.

VMS-based CPUE has shown a great deal of weekly variability during the past five years, but generally remains between 200-500 kg/hour (Fig. 127). The fishery performed better in 2011 than it did in the previous two years, with 2011 weekly CPUE being higher than those of 2009-2010 for most weeks. CPUE remained greater in 2011 than during 2008-2010 at common removal levels exceeding about 10,000 t (Fig. 127). Unlike most other Divisions, there has been no pattern of seasonal depletion evident in the Div. 3LNO offshore fishery in recent years.

Size distributions from at-sea sampling by observers remained platykurtic from 2005 to 2007, with little change in shape and a primary mode at 110 mm CW (Fig. 128). During this time, a reduction in catch rates occurred for all sizes of legal-sized crabs. In 2008, there was a dramatic change in the size distribution, with the primary mode shifting to about 92-98 mm CW. This modal shift coincided with an increase in the magnitude of catch rates for crabs from about 80-98 mm CW, likely indicating the entry of a recruitment pulse into legal size. Since then, the mode has gradually progressed to about 98-101 mm CW and the catch rates of crabs of about 89-119 mm CW have increased, indicative of a continued slow progression of a recruitment pulse into the exploitable population. Observer sampling data indicate that the 2010 increase in CPUE was largely due to an increase in new-shelled legal-sized crabs (Fig. 129) and the 2011 catch composition closely reflected that of 2010.

Both the trap and trawl survey exploitable biomass indices increased in 2009 (Table 9, Fig. 130). However, the trawl survey index decreased by 34% since 2009 while the trap survey index increased by 21%. Opposing survey trends create uncertainty about the exploitable biomass. The greatest decreases in catch rates by the trawl survey in the past two years have occurred in the outer portion of the Grand Bank (Fig. 131), where decreases in CPUE occurred in 2011 (Fig. 125).

Production

Recruitment: Recruitment has recently peaked and will likely decrease in the short term. Both post-season surveys indicated that pre-recruit biomass was at a high level from 2008 to 2010 but declined sharply in 2011 (Table 9, Fig. 132). The trawl survey indicates the abundance of pre-recruit crabs decreased throughout the Division in 2011 with the exception of the Div. 3N slope (Fig. 133).

The catch composition of exploitable crabs in the trawl survey shows that a trend of increasing levels of new-shelled males (immediate pre-recruits) that began in 2007 peaked in 2009 and declined since (Fig. 134). This was followed by an increase in intermediate-shelled crabs that began in 2009, peaked in 2010, and started to decline in 2011. The more spatially limited CPS trap survey catch rates of new-shelled legal-sized males shows a similar phenomenon of an increase from 2007 to 2009, but in that survey the abundance of new-shelled males has remained unchanged in the past two years (Fig. 135).

The high level of pre-recruit biomass indices from both trap and trawl surveys during 2008-2010 reflects the prominence of a group of large adolescents in both in the trap and trawl survey size distributions in those years (Fig. 136-137). The sharp decrease in the pre-recruit biomass index from both surveys in 2011 reflects the progression of that modal group to legal size. Most adolescents of this recruitment pulse have now recruited to the exploitable biomass as terminally-molted adults. Small-mesh trap size frequencies from the CPS survey show the progression of this modal group of adolescents from about 41 mm modal CW in 2005 to 89 mm CW in 2009 (Fig. 138). This modal group deteriorated over time due to progressive loss of members to terminal molt and, especially beginning in 2009, due to fishery removals. A small portion of this recruitment pulse, represented by the trailing tail of the modal group has yet to enter legal-size (Fig. 138). Observer discard data are consistent in showing the deterioration of the recent recruitment pulse, with a decrease in the amount of under-sized crabs discarded occurring in 2011 (Fig. 139), following the elevated 2008-2010 levels.

A decline in recruitment in the short term is consistent with the expected negative effect of a very warm oceanographic regime during 2004-2006 on early survival and subsequent recruitment 8 years later during 2012-2014 (Fig. 140). The ocean climate indices imply some possible improvement in recruitment beyond the short term (in 4-6 years). However, long-term recruitment prospects are unfavourable due to a warming oceanographic regime. The overall trend is of a warming regime, with record warm conditions in 2011 (Fig. 140). Data from CPS post-season small-meshed traps (Fig. 138) show no evidence of progression of small adolescent males through size frequency distributions in recent years, while trawl survey size frequencies show a precipitous decrease in abundance of smallest crabs from 2002-2008, with some marginal improvements in 2009-2010, and a subsequent decrease in 2011 (Fig. 136).

Reproduction: The percentage of mature females carrying full clutches of viable eggs has exceeded 80% from 2002 to 2010 but decreased sharply to 60% in 2011 (Fig. 141). The number of mature females captured in the survey has fluctuated at a relatively consistent level since 1997, following a higher level in the mid-1990s. However, it is noteworthy that the 2011 value was the lowest level of mature females observed to date in the survey.

Mortality

Exploitation: The exploitation rate index increased in 2011 following a sharp decrease from 2008 to 2010 (Fig. 142). Maintaining the current level of removals would have an uncertain effect on the exploitation rate in 2012 due to uncertainty in the exploitable biomass.

Indirect fishing mortality: The pre-recruit fishing mortality rate index has remained near its lowest level during the past three years (Fig. 142). The percentage of the total catch discarded in the fishery (Fig. 142) increased sharply in 2008 from a low level during

2004-2007. It has since declined, implying reduced wastage of pre-recruits, primarily sub-legal sized crabs in the fishery in recent years.

The threshold for soft-shell crab closures was changed from 20% to 15% in 2009 in Div. 3LNO (Fig. 143). The prevalence of soft-shelled crab in the catch throughout the season is typically negligible until early June (i.e. week 12) (Fig. 143), about a month and a half later than in Div. 3K. (Fig. 80). Soft-shell crab prevalence has been at low levels throughout the latter portions of the past two years and reached 20% in week 19, when the fishery was all but over, in both years (Fig. 143). This is consistent with the general pattern of soft-shelled crab observed in most years in Div. 3LNO.

Natural Mortality (BCD): BCD generally occurs at lower levels in Div. 3L than in Div. 3K, and has been virtually non-existent in Div. 3NO. Prevalence (in new-shelled males) from offshore Div. 3L fall multi-species trawl surveys (Fig. 144) has been variable with highest incidence during 2003-2005. Prevalence appears to be density-dependent (Mullowney et al 2011). The high prevalence levels during 2003-2005 were likely due to a high density of 40-75 mm CW crabs, which subsequently materialized into the recent recruitment pulse that has entered into the exploitable biomass. The lower prevalence levels of recent years are consistent with the decreased long-term recruitment prospects resulting from a warming oceanographic regime.

DIVISION 3L INSHORE

The Fishery

The Div. 3L inshore fishery occurs in coastal bays and in the near-shore region, within 25 nautical miles (nm) of headlands (Fig. 120). Landings peaked in 1996 at 7,900 t (Table 8, Fig. 145). They declined to 4,700 t in 2000, increased to 6,800 t in 2003, and decreased slightly to 2005 due to changes in the TAC. They increased by 19% from 6,100 t in 2005 to 7,300 t in 2010 and decreased slightly to 7,100 t in 2011. Effort increased by 24% from 2008 to 2010 but decreased slightly in 2011 (Table 8, Fig. 145). CPUE (Table 8, Fig. 146) has varied between 8-12 kg/trap since the early 1990s.

There has been little change in the distribution of the fishery over the past four years (Fig. 147). Most of the bays and coastal areas of Div. 3L receive considerable fishing effort each year, and there is little room for expansion within most CMAs. The temporal distribution of the 2011 fishery closely resembled the 2009 fisheries (Fig. 148), early in relative terms for the recent timeframe. The fishery began in early April with most effort expended by late June.

Biomass

CPUE increased from 2004 to 2008 and decreased in 2009 (Table 8, Fig. 146). It has remained at the long-term average for the past three years. A high level of bias created by spatiotemporal inconsistency in the distribution of observer coverage among the various CMAs (Fig. 149) creates uncertainty in observer-based CPUE at the Divisional level, and does not allow for interpretation of observer-based CPUE in some CMAs (Fig. 150). In the past two years the spatial coverage of observer deployments across CMAs has improved with all management areas receiving coverage at more proportional levels. However, the level of variability that still remains in annual coverage makes the reliability of observer data as the basis for fishery and resource performance indicators highly questionable and largely inadequate for stock assessment purposes.

There has been a general inverse relationship between the areal extent of the fishery and commercial CPUE since 1995 (Fig. 151). However, there has been limited change in the spatial extent of the fishery in recent years. The areal distribution of the fishery consists of two distinct levels, with about 30 to 45% of available 5' x 5' cells occupied each year from 1995 to 2001 and about 70 to 80% of cells occupied each year thereafter. This is attributable to localized spatial expansion of effort throughout the inshore of Div. 3L beginning in 2002, which was most pronounced in coastal regions of the Northeast Avalon and the western half of Conception Bay (Dawe et al., 2003). The sharp increase in spatial coverage of the fishery in 2002 was followed one year later by a sharp decrease in CPUE.

CPUE indices have shown a pattern of depletion throughout the season in recent years (Fig. 152). CPUE tends to be greatest at the beginning of the season each year, ranging from about 12-16 kg/trap, and declines thereafter, generally finishing at less than 8 kg/trap (Fig. 152). With the exception of the first four weeks, most of the weekly CPUE values in the 2011 fishery were about average relative to the five year time series. When measured against cumulative removals, the pattern of depletion becomes most pronounced during the late stages of the fishery in most years, although 2011 was an exception in that catch rates improved during the mid portion of the season and the depletion did not occur until later than normal, after about 4,000 t of removals (Fig. 152). The post-season trap survey index indicates the exploitable biomass has changed little over the past eight years (Fig. 153).

Production

Recruitment: Overall, recruitment prospects have recently improved. The post-season trap survey pre-recruit index increased from 2008 to 2010 and was unchanged in 2011 (Fig. 154). However, there is considerable variability among management areas. Recruitment is expected to remain relatively high in 2011 as reflected by little change in the catch rate of legal-sized new-shelled adults in the CPS trap survey in 2011 following a 2010 increase (Fig. 155). The 2010 increase was primarily due to increased catch rates of small legal-sized crabs ranging from about 95-101 mm CW (Fig. 156) and there was little change in the size frequency distribution in 2011. The catch rate of sub-legal-sized crabs has increased in the survey during the past two years (Fig. 156), which has resulted in the increase in the pre-recruit biomass index (Fig. 154). Recruitment prospects beyond the short-term are unknown.

Mortality

Exploitation: The trap survey-based exploitation rate index decreased slightly in 2011 (Fig. 153). Maintaining the current level of fishery removals would likely result in little change in the exploitation rate, but may increase mortality on soft-shelled immediate pre-recruits in some management areas in 2012.

Indirect fishing mortality: Spatiotemporal inconsistencies in the distribution of observer coverage do not allow for a reliable index of discards at the Divisional level. Data are insufficient to estimate the pre-recruit fishing mortality rate index.

Natural Mortality (BCD): The trend in prevalence of BCD from the DFO trap survey in Conception Bay (Fig. 157) was somewhat similar to that from the multi-species trawl surveys throughout offshore Div. 3L (Fig. 144), but at higher levels of prevalence, with highest prevalence during 2004-2005. Prevalence generally increased to 2000 before decreasing sharply in 2001. It increased during 2002-2005 before decreasing to 2007 and remaining low since, although there were some marginal increases in 2011. The elevated prevalence levels of 2003-2006 are consistent with the subsequent 2009-2011 increases in pre-recruit biomass (Fig. 154) in indicating a recruitment pulse progressing through the population (Mullowney et al 2011).

Spatial Variability: Trends by CMA

CMA 5A (Bonavista Bay): Fishery CPUE has declined substantially during the past three years following the record high level of 2008, as seen in both logbook and observed catch rates (Fig. 150). Observer sampling shows that the 2010 and 2011 catches were dominated by old-shelled crabs (Fig. 159). It appears that a strong recruitment pulse that became legal-sized during 2006-2007 that supported the fishery in recent years has become depleted. However, both the CPS trap survey (Fig. 160) and the DFO trap survey (Fig. 161) indicate a sharp increase in new-shelled legal-sized crabs following the 2011 fishery that bodes well for short-term recruitment. This increase may have been partly due to a reduced TAC (and associated effort) in 2011 that resulted in reduced handling mortality on soft-shelled crab This increase in available exploitable biomass for 2012 is most apparent in crabs ranging from about 95-100 mm CW (Fig. 162-163). Much of the recruitment pulse that contributed to this abrupt increase is yet to achieve legal-size, as indicated by both trap and trawl surveys (Fig. 163-164), which bodes well for short-term recruitment prospects beyond 2012. Fishery discards have remained low since 2005 (Fig. 165), including soft-shell discards (Fig. 166), consistent with the recent low level of recruitment.

CMA 6A (Trinity Bay): Logbook and observed CPUE both increased during the past three years (Fig. 150), with observer CPUE increasing faster. Observer sampling indicates this was attributable to an increase in legal-sized old-shelled crabs from 2008 to 2010 and new-shelled legal-sized crabs in 2011 (Fig. 167-168). However, the scenario of a population dominated by old-shelled crabs does not fit with an increasing biomass, as it does not imply increasing recruitment. Accordingly, there is skepticism associated with observer shell-condition classification in this area from 2008 to 2010. More realistically, the CPS trap survey indicates the population has been dominated by new-shelled crabs in recent years while the old-shelled component of the exploitable biomass has increased gradually (Fig. 169-170). This survey, particularly the new-shelled legal-sized index, has been variable in recent years but shows a higher abundance of most sizes of legal-sized crabs in the past four years than in 2006-2007. Small-mesh traps in the CPS survey have tracked a recruitment pulse of adolescents since 2004, when the mode was at about 35-38 mm CW (Fig. 171), that has contributed to the recently increased exploitable biomass. Observer discards are consistent in showing the emergence of this recruitment pulse into the exploitable population, with gradually increasing discard rates of under-sized males since 2007 (Fig. 172). Similarly, the persistence of frequently high percentages of soft-shelled crabs in the weekly catches since 2007 (Fig. 173) indicates the steady emergence of this recruitment pulse into the exploitable population. Short-term recruitment prospects beyond 2012 may decrease as the majority of this recruitment pulse has now achieved legal-size (Fig. 171).

CMA 6B (Conception Bay): Commercial CPUE has increased since 2005, based on both logbook and observer indices (Fig. 150). Observer sampling shows the increasing CPUE was initially attributable to new-shelled legal-sized crabs from 2006 to 2008 and more recently to increased abundance of old-shelled legal-sized crabs in 2011 (Fig. 174), chronologically indicating the slow emergence of a recruitment pulse into the exploitable population in recent years. This is evident in observer size frequencies which show the overall increasing catch rate of most sizes of legal-sized crabs since 2007 has been concurrent with an increasing proportion of old-shelled crabs in the catch, especially in the past two years (Fig. 175). The CPS (Fig. 176) and DFO (Fig. 177) trap surveys both show increases in the old-shelled component of the exploitable biomass in recent years with variability in new-shelled legal-sized catch rates. Size frequencies from large-mesh traps in the CPS survey show increased levels of sub-legal-sized crabs, ranging from about 83-92 mm CW, in the past three years (Fig. 178). This is consistent with small-mesh traps in both the CPS (Fig. 179) and DFO (Fig. 180) surveys, both of which indicate this build-up of sub-legal-sized crabs primarily constitutes terminally molted adults. This indicates much of the most-recent prolonged recruitment pulse, first evident from BCD monitoring from 2004 to 2007 (Fig. 157), has now terminally molted, either as sub-legal or legal-sized adults. DFO trawl surveys (Fig. 181) are consistent with this scenario, indicating most of the prolonged recruitment pulse has now terminally molted with recent increases in both legal and sub-legal-sized adult crabs. Observer discards are consistent in indicating the slow progression of a prolonged recruitment pulse in recent years, with little change in the catch rates of under-sized (Fig. 182) or soft-shelled (Fig. 182-183) crabs in the catch since 2005. Recruitment prospects are uncertain, but the trawl surveys indicate there is a still some of the recent recruitment pulse remaining, evident as sub-legal-sized adolescents, that could contribute further to the exploitable biomass over the next couple of years, and BCD prevalence has been low from 2007-2011 (Fig. 157), which could indicate reduced recruitment potential beyond the short-term.

CMA 6C (Northeast Avalon): Fishery CPUE has remained relatively consistent, varying between 8-12 kg/trap since 2002 (Fig. 150). This relative consistency in CPUE is reflected by relative consistency in catch rates of legal-sized crabs in the CPS survey, which, with the exception of a spike in 2006, has remained at about 14-16 crabs/trap since 2004 (Fig. 184). Fishery recruitment is expected to change little in 2012, with little change in the catch rates of legal-sized new-shelled males in the CPS survey in 2011 (Fig. 184). There has been little change in the abundance of all sizes of legal-sized crabs in the past five years, although the abundance of sub-legal-sized crabs has increased in the past two years (Fig. 185). A variable but high proportion of the pre-recruit-sized crabs in the CPS survey small-meshed trap catches have been terminally molted adults during the past five years (Fig. 186), thus recruitment prospects beyond 2012 are uncertain.

CMA 8A (Southern Avalon): At 18-22 kg/trap, fishery CPUE has remained relatively high since 2006 (Fig. 150). The CPUE spikes in both 2008 and 2011 followed spikes in new-shelled legal-sized crabs in the CPS trap survey (Fig. 187). These new-shelled spikes were followed by subsequent increases in old-shelled legal-sized crabs in both cases, including in 2011. The variable nature of the trap survey performance each year, in both sub-legal and legal-sized crabs (Fig. 188), renders predictions about recruitment prospects difficult.

CMA 9A (St. Mary's Bay): Commercial CPUE has varied between about 15-23 kg/trap since 1999 (Fig. 150), with a sharp decline in 2008 followed by slight increases from 2009 to 2011. Observer sampling indicates a build-up of small legal-sized crabs in the past two years (Fig. 189). However, the old-shelled nature of the population is not consistent with the emergence of a recruitment pulse into legal-size, thus there is skepticism associated with shell classification in this area. The CPS trap survey shows the legal-sized population is dominated by new-shelled crabs (Fig. 190), with a tripling in catch rates of new-shelled legal-sized crabs from 2008 to 2010. This indicates the emergence of a recruitment pulse into legal-size, evident in size frequency distributions (Fig. 191), which also showed that only the leading tail of the pulse had entered in 2010. In 2011 a higher proportion of this recruitment pulse had achieved legal-size, although the mode was still centered at about legal-size (ie. 95 mm CW), indicating there should be a further contribution of this recruitment pulse to the exploitable biomass in the next couple of years. This is consistent with small-mesh trap samples from the CPS survey

(Fig. 192), which show the progression of a pulse of sub-legal-sized adolescents into legal-size during the past two years, with the trailing tail yet to enter. Soft-shelled crab has been evident in observer sampling during the past two years as the recruitment has entered into the exploitable biomass, but the generally low levels of 5-10% in most weeks (Fig. 193) imply a relatively low level of fishery-induced mortality.

SUBDIVISION 3PS OFFSHORE

The Fishery

The Subdiv. 3Ps offshore fishery occurs off the south coast of Newfoundland in areas associated with the St. Pierre and Green banks (Fig. 194). Landings (Table 10, Fig. 195) varied little, at 4,300-4,400 t during 1999-2002, before declining by about half to 2006. They almost doubled from 2,300 t in 2006 to 4,300 t in 2011. Meanwhile effort (Table 10, Fig. 195) decreased from 2006 to 2008 and since increased by 56%. CPUE declined substantially from 1999 to 2005. It increased from 2005 to 2009 and has since declined slightly (Table 10, Fig. 196).

The spatial distribution of the fishery has remained similar over the past four years (Fig. 197) but there have been some subtle changes. In most years, the bulk of offshore fishing effort is expended in Halibut Channel between the St. Pierre and Green banks (Fig. 197). In 2010-2011, the effort was more concentrated in the northern portion of Halibut Channel than in most previous years. The effort on the slope along the northwest portion of the St. Pierre Bank has also increased during the past four years. The temporal distribution of the 2010 fishery was also delayed relative to the previous four years, with a minimal amount of effort expended before May and the fishery extending into late July (Fig. 198). The temporal distribution of the 2011 fishery was earlier than in 2010 and generally similar to that during 2007-2009, beginning in early April with most effort expended by mid-June. The management shift toward a spring fishery has been more successful in Subdiv. 3Ps than in any other Division. This is likely due in large part to a lack of spring ice cover along the south coast. The delay in the 2010 fishery was attributable to a price dispute early in the season.

Biomass

Declines in CPUE occurred throughout the offshore in 2011 but were most extreme in the outer-most fishing areas (Fig. 199). The offshore fishery performed more poorly than did the inshore fishery in 2011. The spatial coverage of the fishery has generally been inversely related to commercial CPUE since 1999 (Fig. 200). The percentage of available 5' x 5' cells occupied by the fishery increased steadily from 1995 to an initial peak in 2002. It then declined gradually in 2003 and 2004 before increasing sharply to its highest level of 75% in 2005. This is likely attributable to a high incidence of soft-shelled crab in the fishery in 2005 (Dawe et al., 2006). The spatial index declined sharply in 2006 but has since gradually increased.

Catch rates have shown high levels of weekly variability, but show that the fishery has performed better throughout the season during each of the past four years than it did in 2007 (Fig. 201). The 2011 fishery performed similarly to the fisheries of other recent years throughout most of the season. However, near the end of the season, following week 12, CPUE declined to levels not recently observed. This was associated cumulative removal levels greater than about 3200 t, not achieved in previous years.

Size distributions from at-sea sampling by observers (Fig. 202) showed a sharp ('knife-edge') decrease in catch rate at 95mm CW from 2005-2007, suggesting high fishery exploitation on legal-sized crabs. This knife-edge effect was not present in 2008-2011, with increased catch rates of most sizes of legal-sized crabs. However, there were some slight decreases in largest crabs, of about 107 mm CW and greater, in 2011. The high catch rates of undersized (<95 mm CW) crabs in most years, and the high proportion of those that were old-shelled, suggests that crabs terminally molt to adulthood at small sizes in Subdiv. 3Ps relative to most other areas.

The observed catch rate of legal-sized new-shelled crabs decreased sharply in 2001, followed by a sharp decrease in catch rate of legal-sized old-shelled crabs in 2003 (Fig. 203). Catch rates of old-shelled crabs have consistently been higher than those of new-hard-shelled crabs, and catch rates of soft-shelled crabs have been virtually nil each year after 1999, with the exception of 2005. Both the new and old-shelled components gradually increased from 2007 to 2009. A decrease in the old-shelled legal-sized crabs occurred in 2010 while a slight decrease in new-shelled legal-sized crabs occurred in 2011. However, catch rates of both components of the exploitable biomass remain above levels observed from 2005 to 2007.

The exploitable biomass, as indicated by both the spring trawl survey and the post-season trap survey indices, increased steadily from 2006 to 2009 and has since declined sharply to 2011 (Table 11, Fig. 204). Generally, the greater the distance from shore, the greater the decreases in catch rates of exploitable crabs by the trawl survey in the past two years (Fig. 205). Very few crabs were captured in Halibut Channel in the 2011 survey relative to most previous years.

Production

Recruitment: Recruitment has recently declined and is expected to decline further in the short term. Post-season pre-recruit biomass indices from both trap and trawl surveys increased in 2009 and have since declined sharply to 2011 (Table 11, Fig. 206). Similar to exploitable crabs, there is a general pattern of decreasing catch rates of pre-recruit crabs by the survey trawl with distance from shore and few crabs were captured in the Halibut Channel in 2011 (Fig. 207).

This recent decline in recruitment is reflected in a decrease in biomass of new-shelled legal-sized crabs beginning in 2010 and the subsequent decrease in older-shelled crabs in 2011. This phenomenon is apparent in data from both the trawl survey (Fig. 208) and the CPS trap survey (Fig. 209).

Size distributions from the spring trawl survey showed a modal group of adolescent crabs approaching legal-size in 2007-2009 that has since dissipated (Fig. 210). The advancement of this recruitment pulse into legal-size is also reflected in CPS trap survey size frequencies, which show the primary mode in the population occurred at 89 mm CW in 2007, progressed to 92 mm CW in 2009, and subsequently increased further to 95 mm CW in 2011 (Fig. 211). Meanwhile, catch rates of new-shelled legal-sized crabs of all sizes have decreased in the past two years. Small-meshed size frequency distributions from the CPS survey clearly show the high proportion of small terminally-molted adults that characterizes this Subdivision (Fig. 212). This is attributable to the very cold bottom conditions that dominate this Subdivision (Dawe et al., 2012). These size frequencies show few under-sized adolescents remaining in the population to contribute to future recruitment into the exploitable biomass.

At-sea observer sampling showed a decrease in catch rate of under-sized crabs in 2010 and little change in 2011 (Fig. 213). These observer data show that virtually all discards in the fishery have been under-sized crabs since 2005, with no indication of soft-shelled crabs in the catch in recent years (Fig. 213).

Fishery CPUE is inversely related to a lagged (seven year) index of bottom temperature at shallow depths in offshore Subdiv. 3Ps and directly related to the spatial extent of <1°C water at the same lag (Fig. 214). These ocean climate indices imply some possible improvement in recruitment in the near future (around 2014-2015), due to a relatively cold ocean climate regime 7 years earlier during 2007-2008 (Fig. 214), that is inconsistent with the survey indices (Fig. 206) but may be reflected in the increased abundance of smallest crabs in 2009-2010 (Fig. 210). However, long-term recruitment prospects are unfavourable due to a warming oceanographic regime. The overall trend is of a warming regime, with very warm conditions in 2011 (Fig. 214). Data from CPS post-season small-meshed traps show no evidence of progression of small adolescent males through size frequency distributions in recent years (Fig. 212).

Reproduction: The number of females captured increased sharply from 2001 to 2002, and has since declined to its lowest level, in 2011 (Fig. 215). There is high annual variability in the percentage of females carrying full clutches of viable eggs (Fig. 215). Greater than 90% of females carried full clutches of eggs from 2008 to 2010, but only 70% carried full viable clutches in 2011.

Mortality

Exploitation: The exploitation rate, as indicated by the spring trawl survey index, decreased from 2007 to 2009 but increased sharply to its highest value since 2007 in 2011 (Fig. 216). Maintaining the current level of fishery removals would likely result in an increase in the exploitation rate in 2012.

Indirect fishing mortality: The pre-recruit fishing mortality rate index decreased from 2007 to 2009 but increased sharply to its highest value since 2003 in 2011 (Fig. 216). The percentage of the total catch discarded in the fishery (Fig. 216) peaked at about 45% in 2005, declined by half to 2008 and has since changed little. Thus, the increase in the PFMI in 2010 and 2011 reflects the declining pre-recruit biomass more than increased discard levels of undersized crabs. The percent discarded in Subdiv. 3Ps is generally higher than in other areas as it includes a larger component of under-sized crabs, an unknown but high portion of which is comprised of small adults that will never recruit to the fishery. Soft-shelled crab has been virtually absent in the observed catch in most recent years but increased in the latter parts of the 2011 season, with prevalence of 5-10% occurring from weeks 13-16 of the fishery (Fig. 217). There has been virtually no observer coverage during these late weeks of the season in previous years. Overall, mortality resulting from catching and handling soft-shelled crab is believed to be minimal in most years.

Natural Mortality (BCD): Small-meshed trap data from the CPS trap survey indicates that BCD has been detected, at low prevalence levels in offshore Subdiv. 3Ps in 2005-2006, but not in 2007-2011 (unpublished data).

SUBDIVISION 3PS INSHORE

The Fishery

The Subdiv. 3Ps inshore fishery occurs in nearshore regions off the south coast of Newfoundland (Fig. 194). Placentia Bay (CMA 10A), to the east of the Burin Peninsula, constitutes the primary fishing grounds. Landings (Table 10, Fig. 218) varied little, at 3,300-3,600 t during 1998-2002, before declining by a factor of 5 to 2005. They then more than tripled from 700 t in 2005 to 2,500 t in 2011. Meanwhile effort (Table 10, Fig. 218) declined from 2005 to 2010 and increased by 22% in 2011. CPUE declined from 2001 to 2005, increased steadily from 2005 to its highest level since 1996 in 2010 and decreased marginally in 2011 (Table 10, Fig. 219).

The spatial distribution of the fishery has changed little over the past five years but there have been some subtle changes (Fig. 220). Most effort is expended in Placentia Bay (CMA 10A, Fig. 194) with Fortune Bay (CMA 11E, Fig. 194) representing a secondary source of effort. The commercial fishery in Fortune Bay (CMA 11E, Fig. 194) has been closed since 2005, with a small-scale monitoring fishery occurring each year since the closure. Within CMA 11E there has been an emergence of effort in a coastal fjord in the northwest of the area since 2007 (Fig. 220) while effort in CMA 11W (Fig. 194) has been variable, being virtually non-existent from 2006 to 2009, with light effort since (Fig. 220). Meanwhile, an inshore fleet allocated quota on the northwest portion of the St. Pierre Bank that did not fish that area from 2006 to 2008 has resumed fishing along the slope edge of the St. Pierre Bank during the past three years (Fig. 220). Temporally, similar to the offshore, the 2010 fishery was delayed in starting relative to the previous four years with a minimal amount of effort expended before May (Fig. 221). The timing of the 2011 fishery was similar to 2007-2009, beginning in early April and virtually completed by the end of June. As in the offshore, the management shift toward a spring fishery has been more successful in Subdiv. 3Ps inshore than in other divisions, likely attributable to the lack of spring ice cover.

Biomass

There has been little change in CPUE throughout most of the inshore during the past three years (Fig. 199). Placentia Bay has consistently performed best but all inshore fishing areas have generally performed better in the past three year than they did from 2006 to 2008. A high level of bias created by spatial and temporal inconsistency in the distribution of observer coverage among the various CMAs (Fig. 222) creates uncertainty in observer-based CPUE at the Subdivisional level, and especially compromises interpretation of CPUE at the CMA level (Fig. 223). In recent years, the distribution of observer coverage between Placentia (CMA 10A) and Fortune (CMA 11E) Bays has been highly inconsistent. For example, virtually all observer coverage occurred in Placentia Bay from 2006 to 2008 but Fortune Bay received the bulk of coverage in 2009 and a relatively even split of observer coverage between the two areas in 2010 was followed by disproportionate coverage in Placentia Bay in 2011 (Fig. 222). This spatial bias is compounded by temporal inconsistencies in the coverage within each CMA from year to year, further compromising the utility of observer data for stock assessment purposes.

The spatial coverage of the fishery has been inversely related to commercial CPUE since 1995 (Fig. 224). With about 15-16% of the grounds covered, the percentage of available 5' x 5' cells occupied by the fishery has been unchanged in the past three years while CPUE has exhibited subtle changes.

Trends in commercial CPUE throughout the season (Fig. 225) indicate that CPUE remained similar to that of the previous two years and higher than during 2007 and 2008 throughout most of the 2011 season. A decline in 2011 CPUE following a peak in week 11 occurred near the end of the fishery, at a cumulative removal level exceeding about 1800 t.

The exploitable biomass, as indicated by the post-season trap survey index, increased substantially between 2006 and 2010 and decreased in 2011 (Fig. 226).

Production

Recruitment: Recruitment decreased in 2011 and is expected to decrease further in the short term. The trap survey pre-recruit biomass index increased in 2007 and has since declined back to the pre-2007 level (Fig. 227). The pre-recruit biomass index for this Subdivision includes a high proportion of small adults that will never recruit to the fishery. The expected decrease in recruitment for the 2012 fishery is reflected in the decreased catch rate of legal-sized new-shelled crabs in the CPS trap survey (Fig. 228). This decrease occurred across all sizes of legal-sized crabs in 2011 but was most apparent in crabs ranging from about 95-100 mm CW (Fig. 229). Longer-term recruitment prospects are uncertain, but the 2011 CPS survey captured fewer undersized crabs than any survey since 2006 (Fig. 229), perhaps suggesting reduced recruitment potential.

Mortality

Exploitation: The post-season trap survey-based exploitation rate index changed little during 2008-2011 (Fig. 226). Maintaining the current level of fishery removals would likely result in an increase in the exploitation rate in 2012.

Indirect fishing mortality: Spatiotemporal inconsistencies in the distribution of observer coverage do not allow for a reliable index of discards at the Divisional level. Data are insufficient to estimate the pre-recruit fishing mortality rate index.

Natural Mortality (BCD): Small-meshed trap data from the collaborative post-season trap survey indicates that BCD was occasionally detected, at low levels prior to 2004 in inshore Subdiv. 3Ps, but absent since (unpublished data).

Spatial Variability: Trends by CMA

CMA 10A (Placentia Bay): Fishery performance has improved substantially from 2006 to 2010, as indicated by both logbook and observer CPUE indices (Fig. 223). A slight decrease in logbook CPUE was opposed by an increase in observer CPUE in 2011. Nonetheless, both indices indicate CPUE remained high in 2011. Observer sampling indicates that the abundance of exploitable crabs has increased in recent years and the catch has been comprised of a roughly even mix of old- and new-shelled crabs in most years since 2005 (Fig. 230). The increased catch rates predominately occurred in small legal-sized adults ranging from about 95-110 mm CW from 2008 to 2010, but extended across a broader size range to larger crabs in 2011 (Fig. 231). However, recruitment for 2012 is likely to decrease, based on the decreased catch rate of legal-sized new-shelled crabs in the 2011 CPS survey (Fig. 232). This decrease in availability of recently recruited exploitable crabs occurred across the entire size range of legal-sized crabs in 2011 (Fig. 233). Longer-term recruitment prospects are uncertain, but small-mesh traps from the CPS survey indicate the majority of sub-legal-sized crabs captured in the past few years have been terminally molted adults (Fig. 234) and give no indication of adolescents progressing through small sizes in the population. However, these traps are spatially limited, generally set in shallow water, thus there is uncertainty in their ability to project recruitment prospects for the area as a whole. The percentage of the catch discarded has dropped by two-thirds since 2006 (Fig. 235), almost wholly attributable to reduced catch rates of undersized crabs, which implies reduced recruitment potential. There has been very little incidence of soft-shelled crabs in the fishery in recent years (Fig. 236), indicating little wastage of the resource.

CMA 11E (Fortune Bay): CPUE has been in a variable, but overall gradually increasing phase since 2003 (Fig. 223). Catch rates of legal-sized crabs in the CPS trap survey have similarly varied each year, but been in an overall gradually increasing phase, with highest catch rates in 2010-2011 (Fig. 237), indicating the exploitable biomass has recently increased. The DFO trap survey shows increased catch rates of legal-sized crabs in the two deep, commercially fished strata (295 and 296) in recent years, with a substantial increase in new-shelled legal-sized crabs in stratum 296 in 2011 (Fig. 238). Size frequency distributions from large-mesh traps in the CPS survey show increased catch rates of all sizes of legal-sized crabs during the past two years (Fig. 239). It appears very few crabs achieve legal-size in this bay. Small-mesh traps in this survey show the progression of a recruitment pulse through small sizes in recent years, but indicate that most of this mode, originally centered about 47 mm CW in 2005, terminally molted as undersized adults during 2007-2010 (Fig. 240). Similarly, small-mesh size frequency distributions from the DFO survey show the emergence of a pulse of small adolescents in 2007, centered at about 50mm CW in all three strata, that have mostly terminally molted as undersized adults during the past three years (Fig. 241). However, it appears some crabs from this recruitment pulse have achieved legal-size, with increased catch rates of legal-sized adults most apparent in stratum 296 in 2011, consistent with the large-meshed traps. The DFO trawl survey also shows this accumulation of legal-sized adult males in stratum 296 in 2011 (Fig. 242). Recruitment to the fishery should be increase in 2012 and perhaps 2013, but long-term recruitment prospects are likely to decrease, evident by the dissipation of the mode of adolescent crabs in all surveys.

CMA 11W (Pass Islands): Commercial CPUE initially peaked at 8 kg/trap in 1998, and declined to a low of 2kg./trap in 2003 (Fig. 223). It increased steadily, to a high of 11 kg/trap in 2009 and since decreased to a near-average level. There is no available information from which to infer recruitment prospects.

DIVISION 4R3PN OFFSHORE

The Fishery

The Div. 4R offshore fishery occurs along the west coast of Newfoundland outside of eight nautical miles from the headlands (Fig. 243). Landings (Table 12, Fig. 244) declined by 83% from 190 t in 2007 to a historical low of 30 t in 2010, but increased to 150 t in 2011. Effort (Table 12, Fig. 244) increased by a factor of four in 2011 following the historical low in 2010. The TAC has not been taken since 2002. CPUE declined from 2004 to a historical low in 2009, increased sharply in 2010, and fell to the 2009 level again in 2011 (Table 12, Fig. 245). CPUE has consistently been low relative to other Divisions.

The fishing pattern has remained similar over the past three years, despite differences in absolute levels of effort (Fig. 246). The main concentrations of effort since 2008 have been in the northwest and northeast portion of the Division and outside of the Bay of Islands along the CMA 12E line (Fig. 243). The levels of effort in these areas have dissipated from 2007 to 2010 but increased in 2011. As in most other Divisions, the 2010 fishery was delayed due to a price dispute, and the temporal distribution of 2011 fishery reflected the 2007-2009 seasons. The 2011 season began in early April and most effort was expended by mid-June (Fig. 247).

Biomass

Despite some spatial variability in CPUE in recent years (Fig. 245), there has been no clear change in any specific portion of the offshore (Fig. 248). CPUE has remained low in all offshore areas for the past six years, rarely exceeding 5 kg/trap. In contrast to other Divisions, CPUE and the spatial extent of the fishery have not shown a tendency to be negatively related over most of the time series (Fig. 249). The spatial extent of the fishery has declined precipitously from 2000 to 2010, to a low of only 5% of the grounds covered in 2010. In 2011 the area fished increased to 9% of the grounds covered. The decline in spatial coverage from 2000 to 2010 was not opposed by increasing CPUE as commonly occurs in other areas; rather it was associated with an overall decrease in CPUE from 2002 to 2007 with little change thereafter.

Commercial CPUE throughout the season was about average in 2011 in relation to the most recent five years (Fig. 250). It was initially high, in week 2, and declined quickly by week 4 to a level at which it remained for the duration of the season. This decline in CPUE occurred after about 25 t of removals (Fig. 251).

The exploitable biomass remains low. The indices from both the post-season trap and trawl surveys increased to their highest values in 2011 (Table 13, Fig. 252). However, survey catches are sporadic each year, resulting in very broad confidence intervals, particularly in 2011, introducing high uncertainty in interpreting annual changes.

The 2010 trawl survey was incomplete in southern areas with no sets south of the Port aux Port Peninsula (Fig. 252). However, as this is not an area where crabs have been captured in recent years, the effect on the biomass index is thought to be negligible in that year. Virtually all exploitable crabs have been captured in the extreme northern portion of the Division during the past six years (Fig. 252).

Production

Recruitment: Recruitment has been low in recent years and prospects are uncertain. The pre-recruit biomass indices from both surveys has changed little over the series (Table 13, Fig. 253). Annual values are associated with broad confidence intervals due sporadic survey catches. Similar to exploitable-sized crabs, virtually all pre-recruit-sized males have been captured in the extreme northern portions of the Division during the past six years (Fig. 254).

Recruitment prospects for the short-term are poor. The CPS trap survey catch rate of new-shelled legal-sized crabs has varied at a very low level of 0-1 kg/trap over the 5-year time series (Fig. 255). The trawl survey size frequencies are consistent with the CPS trap survey in showing a slight improvement in catch rates of legal-sized crabs in 2011, but the absolute values of catches in this survey remain extremely low as well (Fig. 256). Longer-term recruitment prospects are unknown but size frequencies from both large-meshed (Fig. 257) and small-meshed (Fig. 258) traps from the CPS survey show virtually no signs of improved recruitment prospects, with few undersized crabs captured since 2007. The bottom temperature in Div. 4R is warm relative to other Divisions, especially in shallow regions (<200 m) where Snow Crab are thought to most commonly settle. This could explain the low productivity of this area in relation to virtually all other areas surrounding NL. The 4-5 degree bottom temperatures have been consistent since 2004 (Fig. 259).

Mortality

Data are insufficient to calculate exploitation rate and pre-recruit fishing mortality rate indices. The effect of maintaining the current level of removals on the exploitation rate in 2012 is unknown.

DIVISION 4R INSHORE

The Fishery

The Div. 4R inshore fishery occurs in bays and nearshore areas inside of 8 nm from the headlands along the west coast of Newfoundland (Fig. 243). Landings (Table 12, Fig. 260) declined sharply by 80 % from 950 t in 2003 to a historical low of 190 t in 2010 and increased to 450 t in 2011. Effort (Table 12, Fig. 260) declined by 95% from 2004 to 2010 and doubled in 2011. The TAC has not been taken since 2003. CPUE (Table 13, Fig. 261) declined from 2002 to 2007 and has since varied without trend below the long-term average.

The spatial distribution of the fishery has changed since 2008 (Fig. 262). In the past three years there has been an increase in fishing effort in Bay St. George (CMA 12C, Fig. 243), the inner Bay of Islands (CMA 12F, Fig. 253), and CMA 12H in the north. Effort re-emerged in Bonne Bay (CMA 12G) in 2011 following the re-opening of the fishery after a two year voluntary moratorium. Temporally, the fisheries of the past five years have been similar, beginning in early April and running until about mid-June to expend most effort (Fig. 263).

Biomass

Annual trends in CPUE (Fig. 261) are influenced by spatial variation in fishery performance among management areas (Fig. 264). Both CPUE and the spatial extent of the fishery increased sharply in 2002 before steadily declining to 2008 and 2007 respectively (Fig. 265). The spatial extent of the fishery has increased greatly since 2007, to an all-time high, while CPUE has remained relatively low.

Commercial logbook CPUE throughout the season in 2011 was average relative to the most recent five year time series (Fig. 266), generally at 3-5 kg/trap in most weeks. However, this level of CPUE held up in 2011 over a much higher level of removals than in previous years, extending to 200 t of removals in 2011, versus 20-50 t in previous years (Fig. 266). The post-season trap survey exploitable biomass index changed little from 2005 to 2009 but has increased greatly in the past two years (Fig. 267).

Production

Recruitment: Recruitment has recently increased and short-term prospects remain promising in most management areas. The post-season trap survey pre-recruit biomass index increased substantially in 2009 and has since remained above the pre-2009 level (Fig. 268). The CPS trap survey catch rates of new-shelled legal-sized crabs has increased substantially during the past two years, from 3 kg/trap in 2009 to 15 kg/trap in 2011 (Fig. 269). This increase has occurred across the entire size spectrum of legal-sized crabs (Fig. 270). Longer-term recruitment prospects are uncertain.

Mortality

Exploitation: The post-season trap survey-based exploitation rate index decreased from 2007 to 2010 but increased sharply in 2011 (Fig. 267). Increasing fishery removals in 2012 would likely have little effect on the exploitation rate but may increase mortality on soft-shelled immediate pre-recruits in some management areas.

Indirect fishing mortality: The observer data are insufficient to estimate the percentage of the catch discarded in the fishery or to infer wastage of pre-recruits. Data are insufficient to estimate a pre-recruit fishing mortality rate index.

Spatial variability: Trends by CMA

CMA 12C + BSG (Bay St. George): Fishery CPUE was unchanged from 2006 to 2010 but increased by more than 50% in 2011 (Fig. 264). The biomass available for the 2012 fishery has increased considerably, as indicated by a four-fold increase in catch rates of legal-sized crab in the 2011 CPS survey (Fig. 271). This increase is due to an increase in recruitment of new-shelled crabs across the entire size range of legal-sized crabs (Fig. 272), and is attributable to a large portion of a mode of adolescents, that has been tracked in small-mesh traps from the CPS survey since 2008 (Fig. 273), achieving legal size in 2011. Although this bodes well for the fishery in the short-term, longer-term prospects are unknown.

CMA 12E (Outer Bay of Islands): Commercial CPUE peaked at 11 kg/trap in 2002 and has declined since, to a historic low of <3 kg/trap in 2011 (Fig. 264). However, the CPS survey catch rate of legal-sized crabs increased substantially in 2011 following a continuous decline from 2005 to 2010 (Fig. 274). This increase was wholly attributable to an increase in new-shelled crabs, reflecting increased, recruitment. The increase occurred across the entire size range of legal-sized crabs (Fig. 275). Although the recent increase in exploitable biomass bodes well for the fishery in the short-term, longer-term prospects are unknown.

CMA 12F + BOI (Bay of Islands): Commercial CPUE peaked at 12 kg/trap in 2007 and declined markedly to a low level of 3 kg/trap in 2009, with little change since (Fig. 264). However, the CPS survey catch rate of legal-sized crabs increased substantially in 2010-2011 following a decline from 2005 to 2009 (Fig. 276). This recent increase was wholly attributable to an increase in new-shelled crabs, reflecting increased recruitment. The increase occurred across the entire size range of legal-sized crabs (Fig. 277). Small-mesh size frequencies from the CPS survey show there are more sub-legal-sized adolescents approaching legal-size that should contribute further to the exploitable biomass over the few years (Fig. 278). Longer-term recruitment prospects are unknown.

CMA 12G (Bonne Bay): Fishery CPUE plummeted from 2003-08 (Fig. 264), prompting a voluntary fishing moratorium in 2009. The fishery re-opened in 2011. The CPS trap survey indicates that catch rates of legal-sized new-shelled crabs increased greatly from 2007 to 2010, but declined slightly in 2011, implying a slight decrease in recruitment for the 2012 fishery (Fig. 279). However, the exploitable biomass remains high relative to the eight-year survey time series. Based on trends in size-specific catch rates from large-meshed (Fig. 280) and small-meshed (Fig. 281) traps in the CPS survey, it appears the majority of a recent recruitment pulse has now achieved legal-size and is contributing to the exploitable biomass. Longer-term recruitment prospects (beyond 2012) are unknown.

CMA 12D, CMA 12H: There are inadequate data to assess resource status.

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TABLES

Table 1: Annual overall (Div. 2HJ3KLNOP4R) total allowable catch (TAC) and landings.

YEAR	***TAC (t)***	***LANDINGS (t)***
1995	*27,875*	*32,334*
1996	*34,864*	*37,967*
1997	*42,015*	*45,726*
1998	*49,225*	*52,677*
1999	*61,806*	*69,131*
2000	*51,169*	*55,434*
2001	*52,267*	*56,727*
2002	*56,981*	*59,418*
2003	*56,250*	*58,362*
2004	*53,590*	*55,675*
2005	*49,978*	*43,958*
2006	*46,233*	*47,238*
2007	*47,663*	*50,207*
2008	*54,338*	*52,775*
2009	*54,110*	*53,451*
2010	*56,087*	*52,215*
2011	*55,559*	*52,948*

Table 2: Annual total allowable catch (TAC), landings, effort and catch per unit effort (CPUE) for Div. 2H (offshore only).

YEAR	***TAC (t)***	***LANDINGS (t)***	***EFFORT (trap hauls)***	***VMS CPUE (kg/hr)***	***Logbook CPUE (kg/trap)***
2004		*10*	*2,326*	*267.3*	*4.3*
2005		*67*	*10,635*	*305.8*	*6.3*
2006		*152*	*11,014*	*891.0*	*13.8*
2007		*193*	*15,950*	*520.5*	*12.1*
2008	*100*	*141*	*17,195*	*405.8*	*8.2*
2009	*100*	*86*	*10,617*	*359.0*	*8.1*
2010	*100*	*70*	*28,000*	*361.5*	*2.5*
2011	*70*	*12*	*9,231*	*249.5*	*1.3*

Table 3: Fall multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year, for Div. 2H.

YEAR	***EXPLOITABLE CRAB IN 2H***				***PRE - RECRUIT CRAB IN 2H***			
	BIOMASS (t)			***MEAN (kg/set)***	***BIOMASS (t)***			***MEAN (kg/set)***
	ESTIMATE	*Upper*	*Lower*		***ESTIMATE***	*Upper*	*Lower*	
1998	*23*	*231*	*-184*	*0.02*	*12*	*162*	*-138*	*0.01*
1999	*12*	*159*	*-136*	*0.01*	*0*	*0*	*0*	*0.00*
2004	*132*	*307*	*-43*	*0.10*	*404*	*943*	*-135*	*0.29*
2006	*303*	*996*	*-390*	*0.22*	*138*	*276*	*0*	*0.10*
2008	*97*	*443*	*-249*	*0.08*	*63*	*300*	*-175*	*0.05*
2010	*87*	*906*	*-733*	*0.07*	*0*	*0*	*0*	*0.00*
2011	*18*	*252*	*-215*	*0.01*	*0*	*0*	*0*	*0.00*

Table 4: Annual total allowable catch (TAC), landings, effort and catch per unit effort (CPUE) for Div. 2J (offshore only).

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)	Logbook CPUE (kg/trap)
1995	3,050	3,189	393,704		8.1
1996	2,800	3,102	326,526		9.5
1997	2,800	3,183	286,757		11.1
1998	3,500	4,098	284,583		14.4
1999	4,655	5,416	401,185		13.5
2000	3,411	3,682	304,298		12.1
2001	3,340	3,754	426,591		8.8
2002	3,381	3,520	577,049		6.1
2003	2,265	2,510	583,721		4.3
2004	1,780	1,915	531,944	136.1	3.6
2005	1,425	1,509	284,717	181.6	5.3
2006	1,425	1,987	239,398	271.5	8.3
2007	1,570	2,330	258,889	383.2	9.0
2008	2,366	2,408	231,538	335.8	10.4
2009	2,366	2,301	287,625	320.0	8.0
2010	2,127	2,061	271,184	243.3	7.6
2011	2,127	1,921	355,741	263.5	5.4

Table 5: Fall multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year, for Div. 2J.

YEAR	EXPLOITABLE CRAB IN 2J				PRE - RECRUIT CRAB IN 2J			
	BIOMASS (t)			MEAN (kg/set)	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower		ESTIMATE	Upper	Lower	
1995	3472	4806	2138	1.29	2031	2943	1119	0.75
1996	6120	8262	3977	1.92	2965	4321	1608	0.93
1997	10675	16366	4983	3.36	2992	4227	1758	0.94
1998	12667	18226	7109	3.98	3380	4532	2227	1.06
1999	6292	8384	4201	1.98	1156	1977	335	0.36
2000	3555	4525	2584	1.13	1269	1857	681	0.40
2001	3249	4078	2421	1.02	1313	3207	-581	0.41
2002	852	1312	392	0.27	589	2883	-1705	0.19
2003	1015	1686	343	0.32	917	1311	523	0.29
2004	1334	1953	716	0.42	4399	33047	-24248	1.38
2005	2009	10750	-6733	0.63	1657	3655	-341	0.52
2006	3067	10931	-4797	0.96	2158	4797	-480	0.68
2007	2787	4402	1172	0.88	1306	3042	-429	0.41
2008	1976	2922	1029	0.62	1174	4580	-2231	0.37
2009	1464	2566	361	0.46	1675	11754	-8405	0.53
2010	1513	2450	577	0.48	1007	4916	-2901	0.32
2011	976	4786	-3034	0.28	1801	8568	-4966	0.59

Table 6: Annual total allowable catch (TAC), landings, effort and catch per unit effort (CPUE) for inshore and offshore Div. 3K.

YEAR	**INSHORE 3K**				**OFFSHORE 3K**			
	TAC (t)	**LANDINGS (t)**	**EFFORT (trap hauls)**	**LOGBOOK CPUE (kg/trap)**	**TAC (t)**	**LANDINGS (t)**	**EFFORT (trap hauls)**	**VMS CPUE (kg/hr)**
1995	1,950	1,950	237,805	8.2	9,500	10,376	741,143	
1996	3,450	3,267	510,469	6.4	9,500	10,943	835,344	
1997	3,450	3,122	538,276	5.8	10,850	11,674	871,194	
1998	3,040	2,781	487,895	5.7	12,700	14,103	946,510	
1999	3,242	3,460	865,000	4.0	14,950	17,898	1,345,714	
2000	2,275	2,328	485,000	4.8	11,218	13,056	1,186,909	
2001	2,475	2,757	306,333	9.0	11,218	12,519	1,251,900	
2002	3,195	3,481	429,753	8.1	12,183	12,870	1,191,667	
2003	3,425	3,585	535,075	6.7	12,183	12,922	1,242,500	
2004	3,410	3,527	665,472	5.3	12,183	12,943	1,703,026	221.6
2005	3,115	2,707	575,957	4.7	9,745	5,972	853,143	196.6
2006	2,635	2,728	407,164	6.7	7,795	7,984	694,261	312.5
2007	2,820	3,056	308,687	9.9	8,930	9,215	618,456	445.3
2008	3,455	3,456	290,420	11.9	11,620	11,612	708,049	416.1
2009	3,695	3,585	426,786	8.4	12,780	12,599	1,211,442	278.7
2010	3,395	2,807	475,763	5.9	11,045	9,613	1,033,656	236.0
2011	2,997	2,530	477,358	5.3	9,056	8,219	1,081,447	196.2

Table 7: Fall multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year, for Div. 3K.

YEAR	**EXPLOITABLE CRAB IN 3K**				**PRE - RECRUIT CRAB IN 3K**			
	BIOMASS (t)			**MEAN (kg/set)**	**BIOMASS (t)**			**MEAN (kg/set)**
	ESTIMATE	Upper	Lower		**ESTIMATE**	Upper	Lower	
1995	11676	14534	8817	2.84	7424	9924	4925	1.81
1996	20234	24352	16116	4.92	10632	14312	6952	2.59
1997	18712	22724	14700	4.55	13405	17865	8945	3.26
1998	18918	23156	14679	4.60	9992	13912	6071	2.43
1999	8674	11366	5982	2.11	3487	4871	2104	0.85
2000	9976	12668	7283	2.59	9608	13251	5965	2.49
2001	11886	16482	7289	2.89	6681	8933	4429	1.62
2002	9042	11742	6342	2.20	5178	7343	3012	1.26
2003	3644	4603	2685	0.89	2461	4047	875	0.60
2004	5550	7061	4039	1.35	5378	8989	1767	1.31
2005	6969	8897	5041	1.69	5765	7867	3664	1.40
2006	10939	13469	8409	2.78	9971	15093	4848	2.53
2007	16887	22236	11538	4.11	5256	7199	3313	1.28
2008	16157	21399	10914	3.93	8220	12306	4134	2.00
2009	7928	10301	5554	1.93	5684	7796	3573	1.38
2010	6711	8535	4888	1.63	4041	5851	2230	0.98
2011	5962	8309	3614	1.45	4705	7400	2011	1.14

Table 8: Annual total allowable catch (TAC), landings, effort and catch per unit effort (CPUE) for inshore and offshore Div. 3LNO.

YEAR	INSHORE 3L				OFFSHORE 3LNO			
	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	LOGBOOK CPUE (kg/trap)	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1995	6,475	6,795	471,875	14.4	5,175	7,212	389,838	
1996	7,675	7,922	665,714	11.9	7,100	8,494	534,214	
1997	5,850	6,398	627,255	10.2	13,075	14,293	898,931	
1998	7,225	6,882	583,220	11.8	13,250	15,111	873,468	
1999	5,350	5,453	482,566	11.3	24,275	27,329	1,518,278	
2000	4,633	4,731	407,845	11.6	20,502	22,083	1,150,156	
2001	5,615	5,543	518,037	10.7	20,465	22,630	1,197,354	
2002	6,540	6,524	582,500	11.2	22,333	23,528	1,258,182	
2003	6,774	6,814	841,235	8.1	23,703	24,828	1,451,930	
2004	6,255	6,421	823,205	7.8	23,703	24,676	1,701,793	479.6
2005	6,045	6,114	745,610	8.2	23,703	23,557	1,682,643	454.8
2006	6,095	6,229	629,192	9.9	23,703	24,514	1,776,377	433.0
2007	6,105	6,485	584,234	11.1	23,703	24,405	2,033,750	426.1
2008	7,033	6,823	554,715	12.3	24,148	23,375	2,105,856	323.2
2009	7,210	7,091	662,710	10.7	21,769	21,942	1,924,737	334.3
2010	7,449	7,283	687,075	10.6	24,195	24,136	1,736,403	392.0
2011	7,122	7,069	642,636	11.0	26,100	25,846	1,886,569	413.4

Table 9: Fall multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch by year for Div. 3LNO. The multi-species survey was incomplete in 2004 and 2006.

YEAR	EXPLOITABLE CRAB IN 3LNO				PRE - RECRUIT CRAB IN 3LNO			
	BIOMASS (t)			MEAN (kg/set)	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower		ESTIMATE	Upper	Lower	
1995	31839	40594	23083	3.09	17719	23358	12081	1.72
1996	37461	45018	29903	3.68	26733	36837	16629	2.62
1997	24527	30227	18827	2.39	16266	61740	-29207	1.58
1998	34288	42552	26024	3.33	21015	40946	1084	2.04
1999	20822	25163	16480	2.04	10940	15694	6186	1.07
2000	15507	19841	11172	1.53	10416	13969	6863	1.03
2001	24501	31053	17950	2.38	10159	13405	6913	0.99
2002	19304	25312	13297	1.88	5615	8519	2711	0.55
2003	15363	19789	10937	1.50	8234	14106	2362	0.80
2004	9638	15675	3601	1.04	3831	9389	-1727	0.41
2005	15725	27161	4288	1.53	4582	7095	2069	0.45
2006	5027	6541	3513	0.49	2637	3865	1409	0.26
2007	9711	14600	4822	0.94	8072	11083	5062	0.78
2008	14991	19360	10622	1.46	16457	23298	9615	1.60
2009	22397	31968	12826	2.18	19054	26373	11735	1.85
2010	18279	27466	9093	1.78	17682	27416	7948	1.72
2011	14891	19288	10494	1.45	8808	42478	-24861	0.86

Table 10: Annual total allowable catch (TAC), landings, effort and catch per unit effort (CPUE) for inshore and offshore Subdiv. 3Ps.

YEAR	INSHORE 3Ps				OFFSHORE 3Ps			
	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	LOGBOOK CPUE (kg/trap)	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1995	1,200	1,035	161,719	6.4	525	894	45,846	
1996	1,350	1,309	73,955	17.7	1,700	1,665	99,701	
1997	2,400	2,305	187,398	12.3	2,200	2,370	117,910	
1998	2,500	3,367	333,366	10.1	3,700	3,257	134,033	
1999	3,701	3,598	342,667	10.5	4,298	4,307	177,975	
2000	3,300	3,501	350,100	10.0	4,400	4,386	212,913	
2001	3,200	3,436	279,350	12.3	4,400	4,403	271,790	
2002	3,200	3,280	410,000	8.0	4,400	4,357	360,083	
2003	2,520	2,369	415,614	5.7	3,565	3,750	451,807	
2004	1,630	1,302	372,000	3.5	2,765	3,418	421,975	217.5
2005	1,300	705	207,353	3.4	2,800	2,468	398,065	159.7
2006	975	781	100,128	4.0	2,070	2,324	309,867	179.8
2007	975	1,146	146,923	5.6	2,270	2,816	375,467	200.9
2008	1,128	1,426	128,468	8.7	3,230	3,097	279,009	257.0
2009	1,500	1,939	152,677	12.3	3,780	3,620	287,302	289.5
2010	1,900	2,161	186,293	14.0	4,305	3,865	336,087	276.3
2011	2,462	2,456	250,612	13.0	4,565	4,261	434,796	260.0

Table 11: Spring multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year, for Subdiv. 3Ps. The multi-species survey was incomplete in 2006.

YEAR	EXPLOITABLE CRAB IN 3Ps				PRE - RECRUIT CRAB IN 3Ps			
	BIOMASS (t)			MEAN (kg/set)	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower		ESTIMATE	Upper	Lower	
1996	4535	7943	1128	1.88	1839	3582	96	0.76
1997	1119	1691	547	0.47	291	522	59	0.12
1998	1476	2273	679	0.61	601	1086	116	0.25
1999	2528	4429	626	1.05	324	466	181	0.13
2000	927	1390	465	0.38	235	443	26	0.10
2001	500	801	199	0.21	311	614	7	0.13
2002	427	618	236	0.18	309	478	140	0.13
2003	433	1167	-301	0.18	97	196	-1	0.04
2004	211	308	114	0.09	209	336	82	0.09
2005	503	803	203	0.21	437	630	244	0.18
2006	18	74	-37	0.03	51	122	-21	0.07
2007	246	411	81	0.10	780	1768	-209	0.32
2008	379	570	189	0.16	1058	2966	-849	0.44
2009	935	1599	272	0.39	1422	2382	462	0.59
2010	790	1313	268	0.33	460	1038	-117	0.19
2011	430	693	167	0.18	196	326	66	0.08

Table 12: Annual total allowable catch (TAC), landings, effort and catch per unit effort (CPUE) for inshore and offshore Div. 4R and Subdiv. 3Pn.

YEAR	INSHORE 4R3Pn				OFFSHORE 4R3Pn			
	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	LOGBOOK CPUE (kg/trap)	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1998	1,310	1,067	197,593	5.4				
1999	690	988	161,967	6.1	645	629	149,762	
2000	785	954	190,800	5.0	645	674	134,800	
2001	909	1,026	190,000	5.4	635	649	147,500	
2002	904	878	100,920	8.7	845	977	195,400	
2003	1,050	954	117,778	8.1	845	608	168,889	
2004	1,016	877	139,206	6.3	838	584	182,500	120.0
2005	1,000	511	81,111	6.3	845	348	108,750	115.4
2006	860	460	85,185	6.9	675	79	22,571	89.7
2007	750	368	85,581	3.8	540	194	77,600	89.7
2008	718	250	65,789	4.8	540	131	37,429	81.8
2009	483	199	53,784	4.0	418	88	31,429	74.7
2010	482	188	50,811	3.7	418	33	10,000	107.4
2011	615	446	94,894	4.7	414	149	51,379	77.5

Table 13: Summer multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year, for Div. 4R and Subdiv. 3Pn.

YEAR	EXPLOITABLE CRAB IN 4R3Pn				PRE - RECRUIT CRAB IN 4R3Pn			
	BIOMASS (t)			MEAN (kg/set)	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower		ESTIMATE	Upper	Lower	
2004	111	292	-70	0.15	195	917	-527	0.26
2005	82	273	-109	0.15	14	74	-46	0.02
2006	180	431	-72	0.22	46	116	-24	0.06
2007	92	261	-77	0.11	54	260	-151	0.07
2008	177	555	-202	0.22	52	121	-17	0.06
2009	229	1099	-640	0.28	74	337	-189	0.09
2010	80	188	-28	0.1	18	52	-16	0.02
2011	365	820	-90	0.45	94	861	-127	0.12

FIGURES

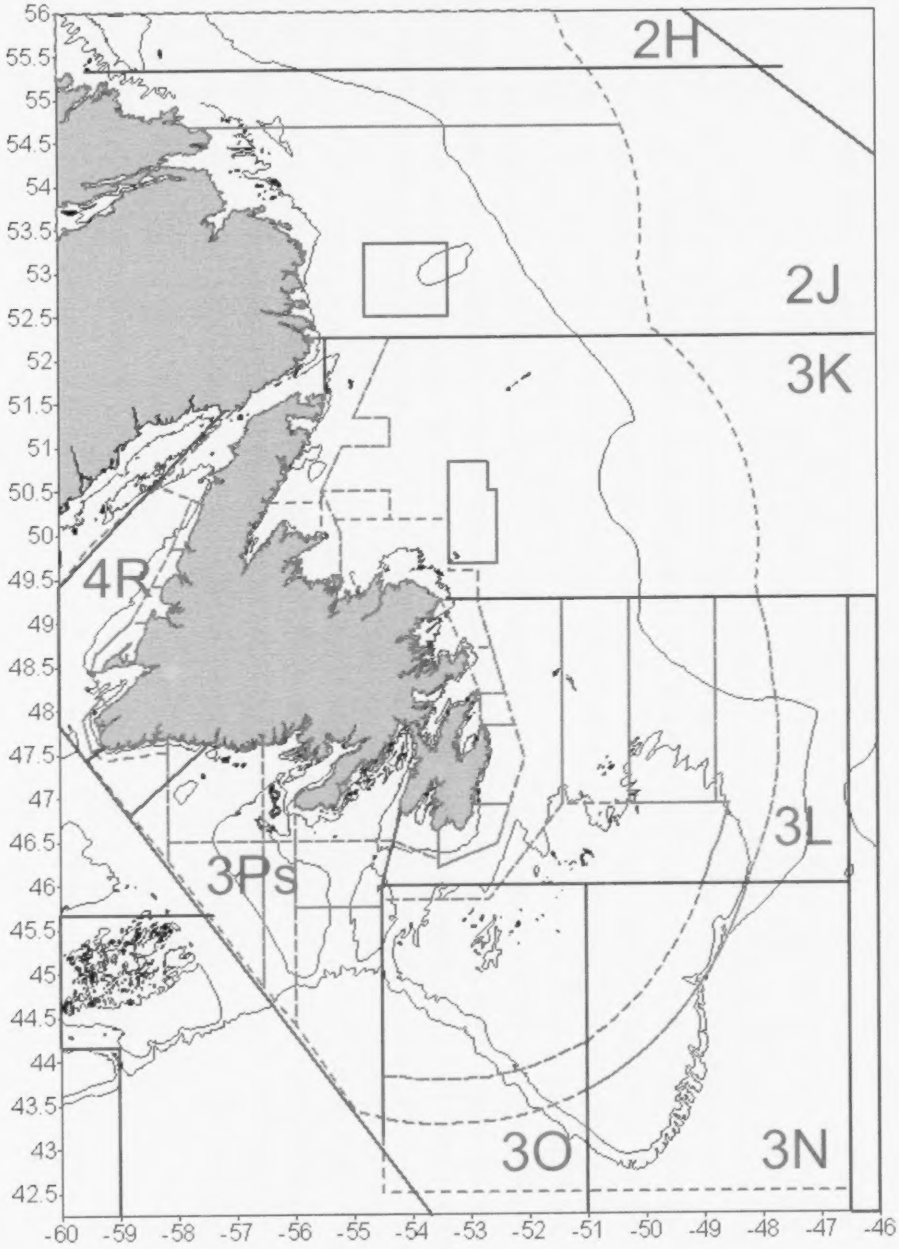

2H
2J
3K
4R
3L
3Ps
3O
3N
56
55.5
55
54.5
54
53.5
53
52.5
52
51.5
51
50.5
50
49.5
49
48.5
48
47.5
47
46.5
46
45.5
45
44.5
44
43.5
43
42.5
-60
-59
-58
-57
-56
-55
-54
-53
-52
-51
-50
-49
-48
-47
-46

Figure 1

Figure 1: NAFO Divisions (purple lines), Newfoundland and Labrador Snow Crab Management Areas (CMA) (green lines), trawling and gillnetting closures (blue boxes), and bathymetry of the Newfoundland and Labrador shelf (grey underlay).

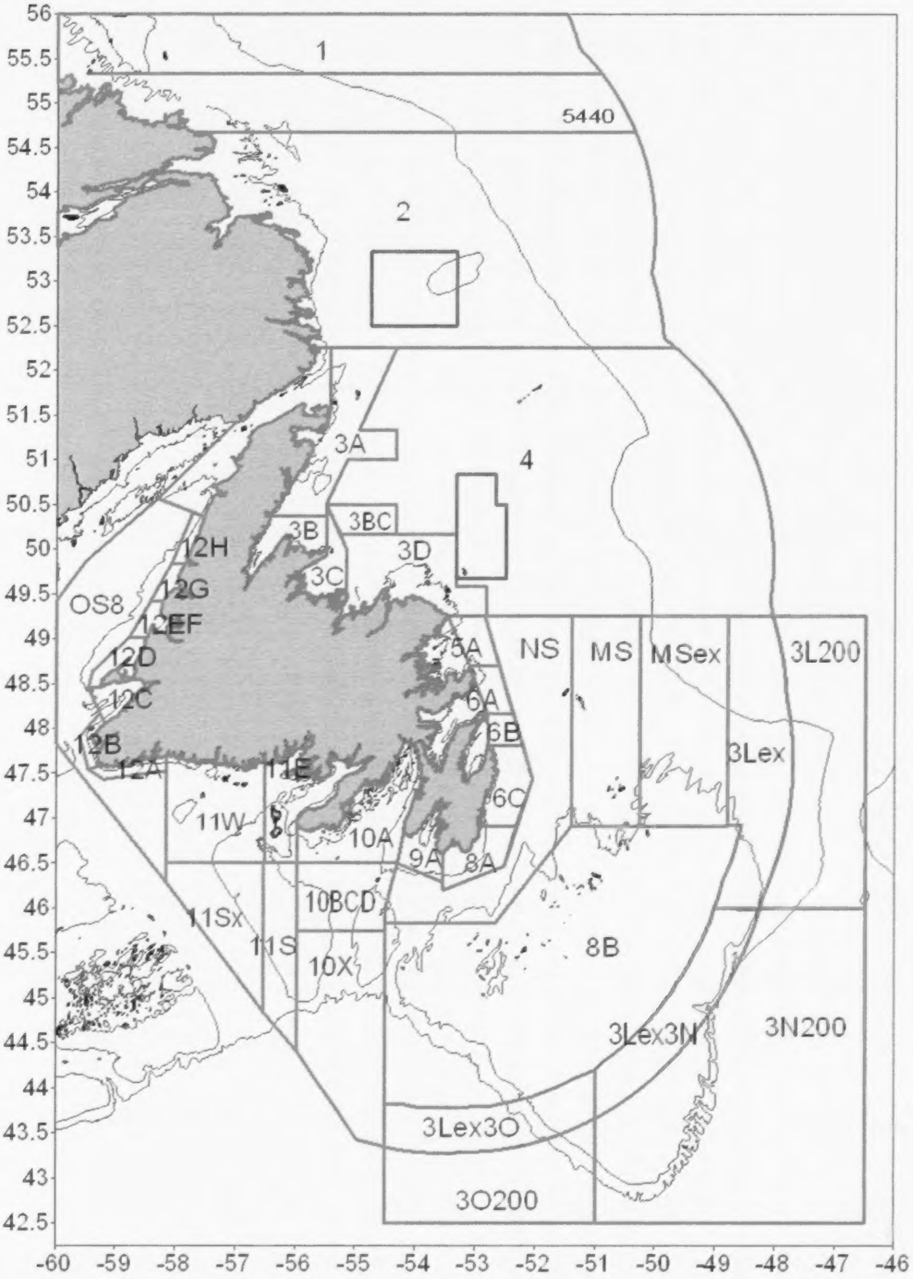

1
5440
2
3A
4
3BC
3B
3D
12H
3C
12G
OS8
12EF
12D
5A
NS
MS
MSex
3L200
12C
6A
6B
3Lex
12B
12A
11E
6C
11W
10A
9A
8A
10BCD
11Sx
11S
8B
10X
3Lex3N
3N200
3Lex3O
3O200
56
55.5
55
54.5
54
53.5
53
52.5
52
51.5
51
50.5
50
49.5
49
48.5
48
47.5
47
46.5
46
45.5
45
44.5
44
43.5
43
42.5
-60
-59
-58
-57
-56
-55
-54
-53
-52
-51
-50
-49
-48
-47
-46

Figure 2: Newfoundland and Labrador Snow Crab Management Areas (CMA).

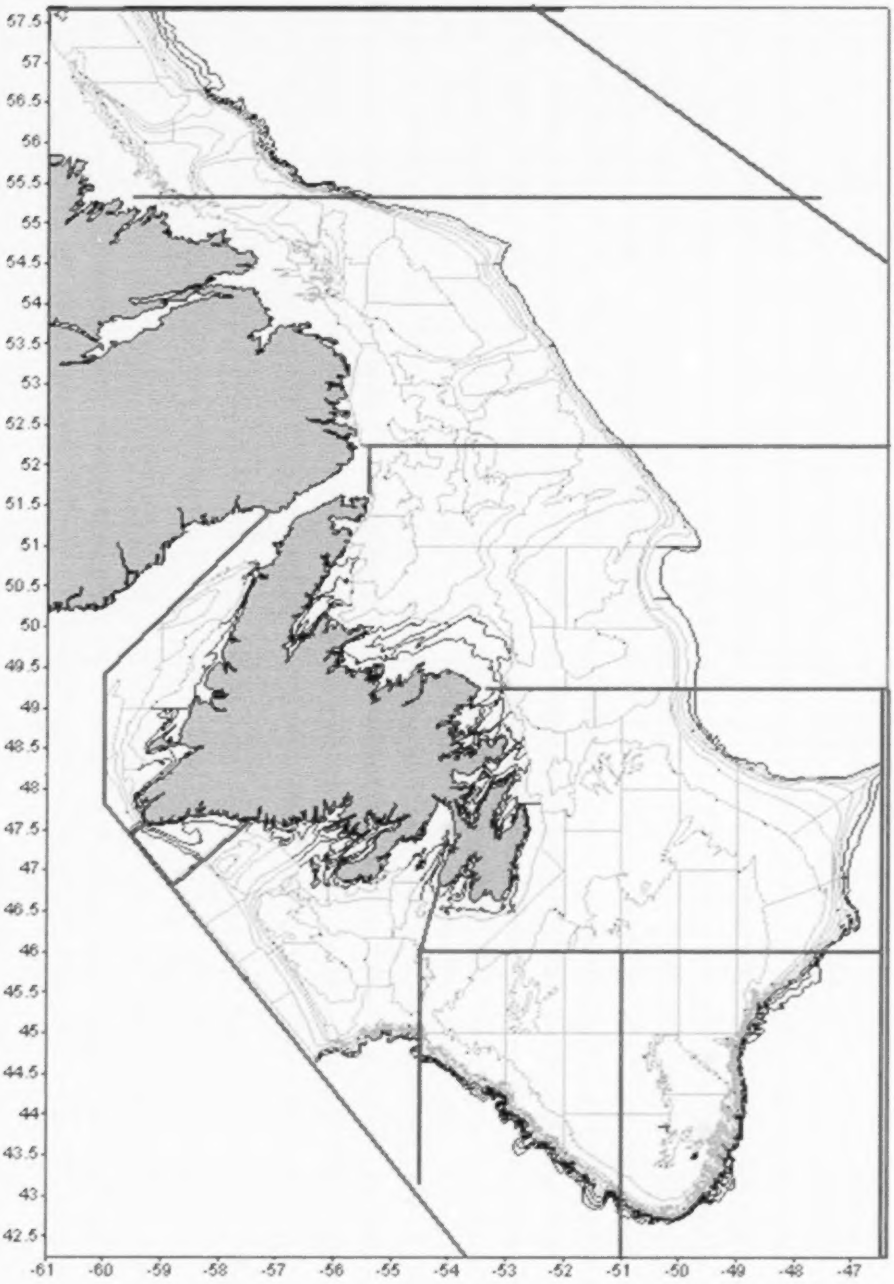

57.5
57
56.5
56
55.5
55
54.5
54
53.5
53
52.5
52
51.5
51
50.5
50
49.5
49
48.5
48
47.5
47
46.5
46
45.5
45
44.5
44
43.5
43
42.5
-61
-60
-59
-58
-57
-56
-55
-54
-53
-52
-51
-50
-49
-48
-47

Figure 3: DFO multi-species trawl survey strata. Core strata shown in teal.

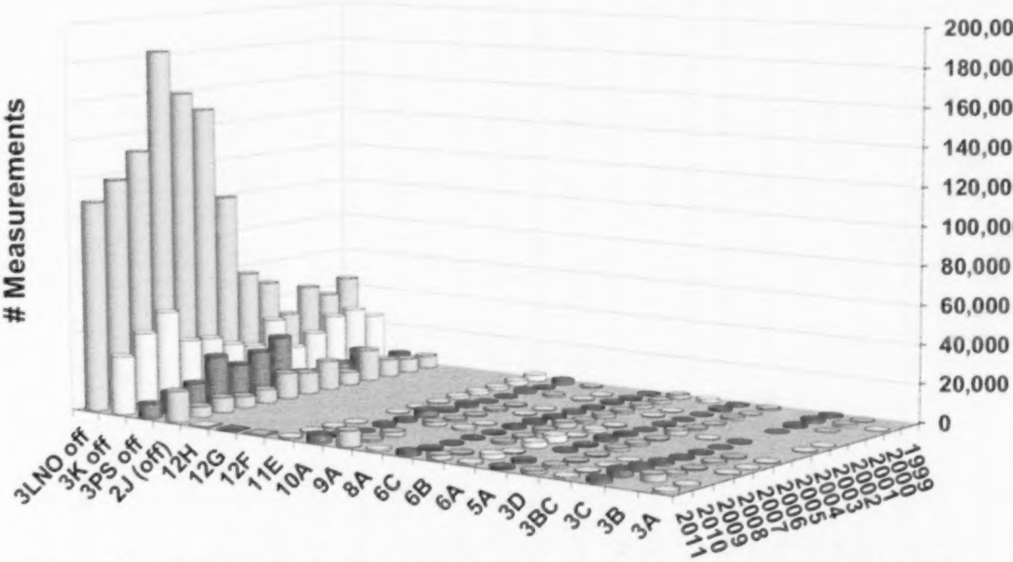
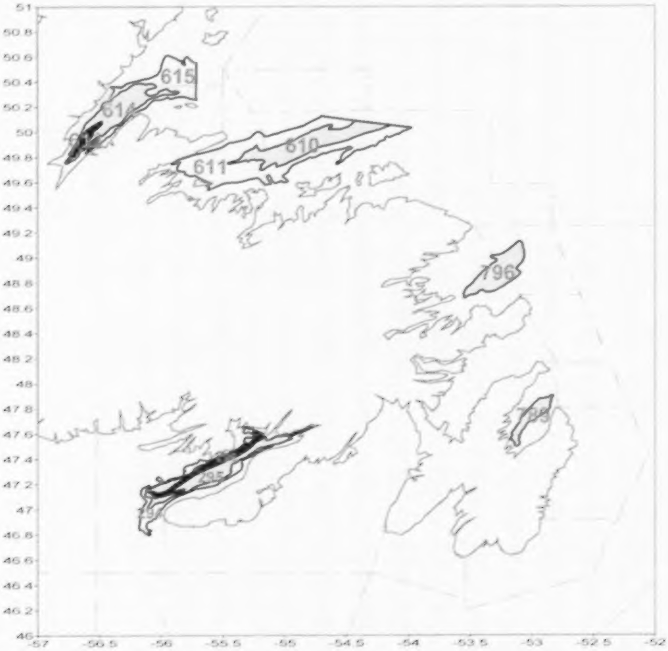


Figure 4: Observer sampling by Crab Management Area (CMA) and year. Data pooled for offshore CMAs in each Division.



51
50.8
50.6
50.4
50.2
50
49.8
49.6
49.4
49.2
49
48.8
48.6
48.4
48.2
48
47.8
47.6
47.4
47.2
47
46.8
46.6
46.4
46.2
46
-57
-56.5
-56
-55.5
-55
-54.5
-54
-53.5
-53
-52.5
-52
615
614
610
611
796
295

Figure 5: Strata sampled during DFO inshore trap and trawl surveys.

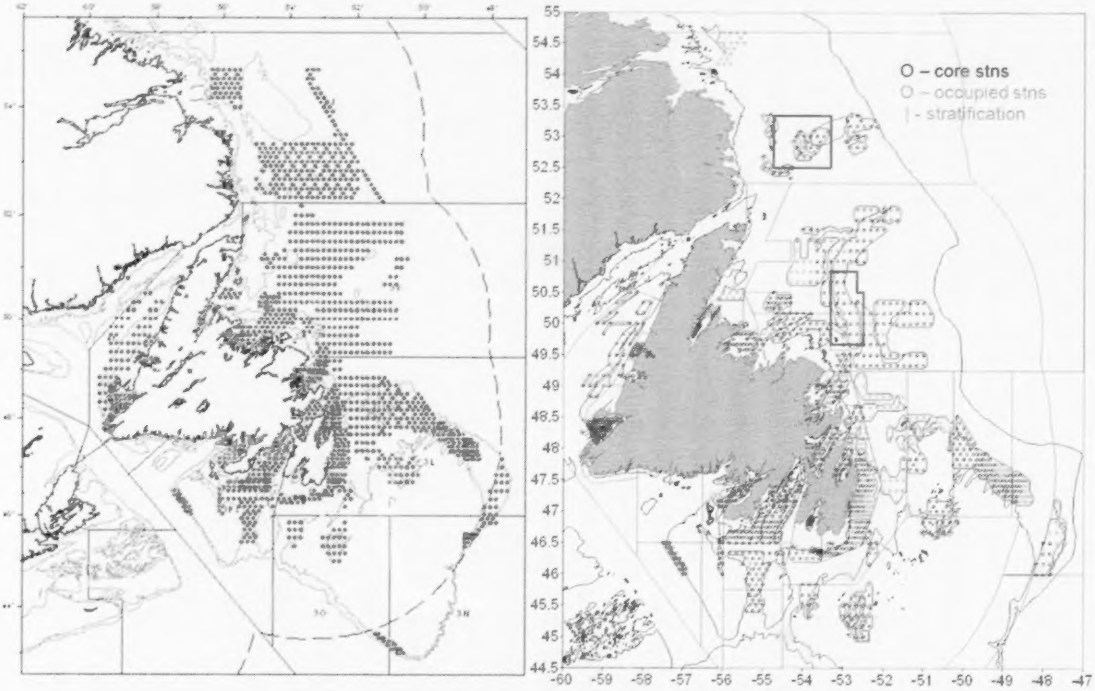

O – core stns
O – occupied stns
| - stratification
55
54.5
54
53.5
53
52.5
52
51.5
51
50.5
50
49.5
49
48.5
48
47.5
47
46.5
46
45.5
45
44.5
-60
-59
-58
-57
-56
-55
-54
-53
-52
-51
-50
-49
-48
-47
3L
3O
3N

Figure 6: Industry – DFO Collaborative Post-Season trap survey design (left). Occupied, and core stations (right), as well as stratification scheme used for data analyses (right).

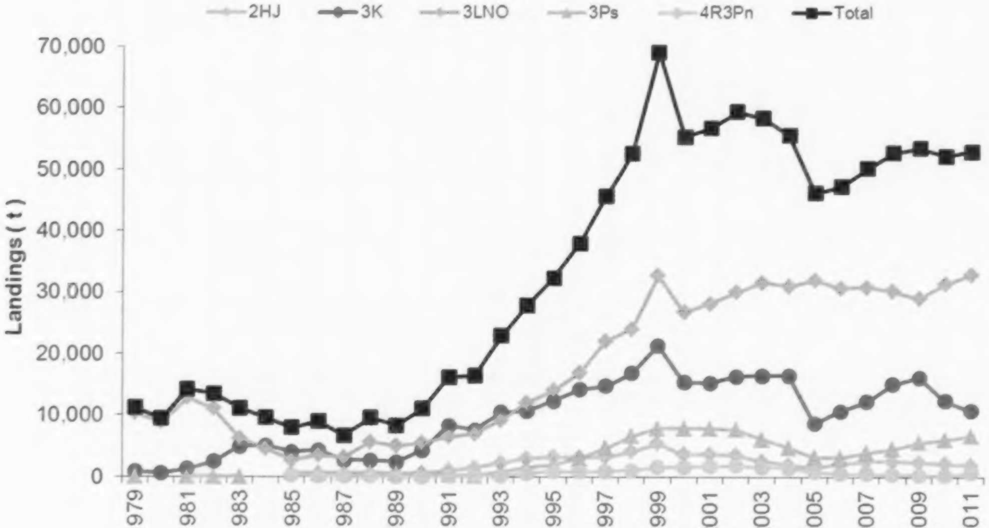


Figure 7: Crab landings for 1979 to 2011 by total and Division.

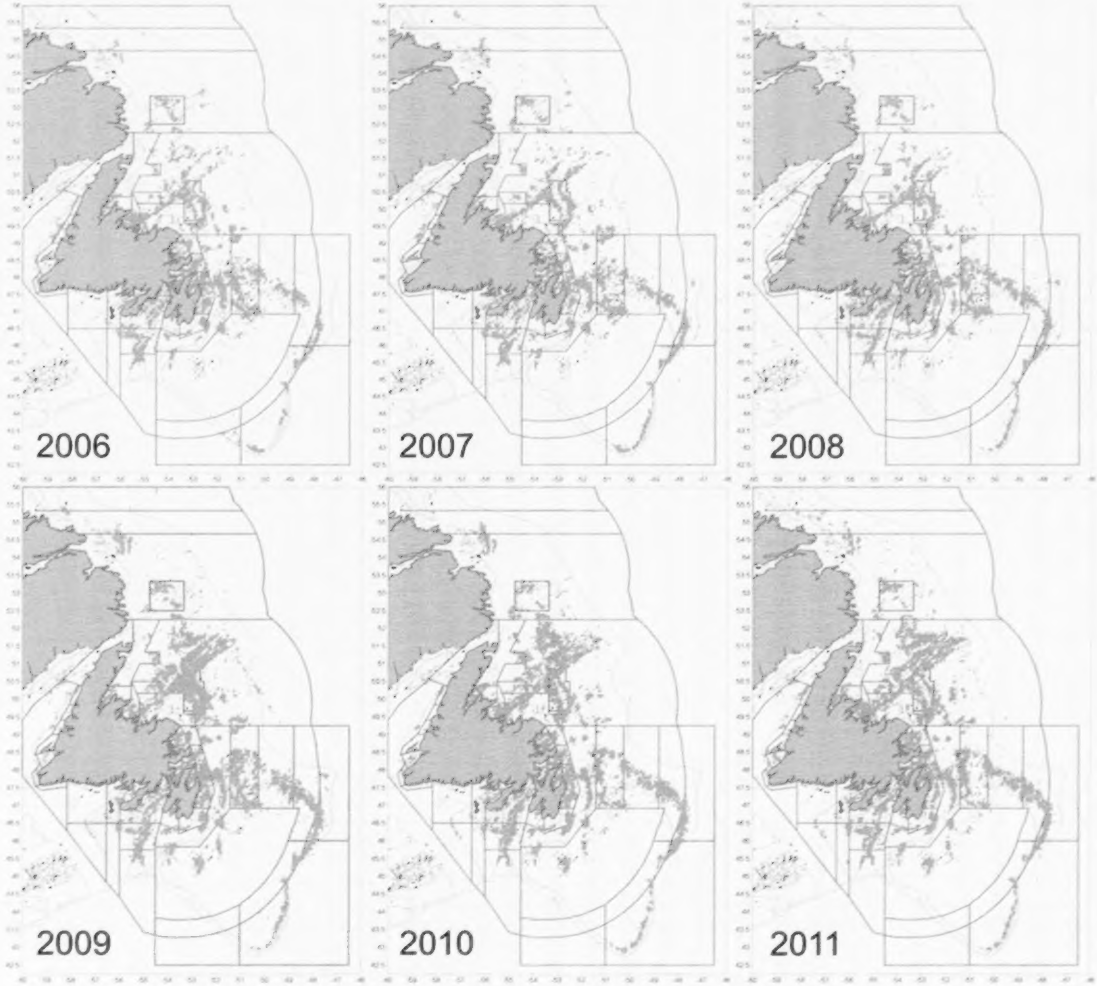

2006
2007
2008
2009
2010
2011

Figure 8: Distribution of logbook fishing effort from 2006 to 2011.

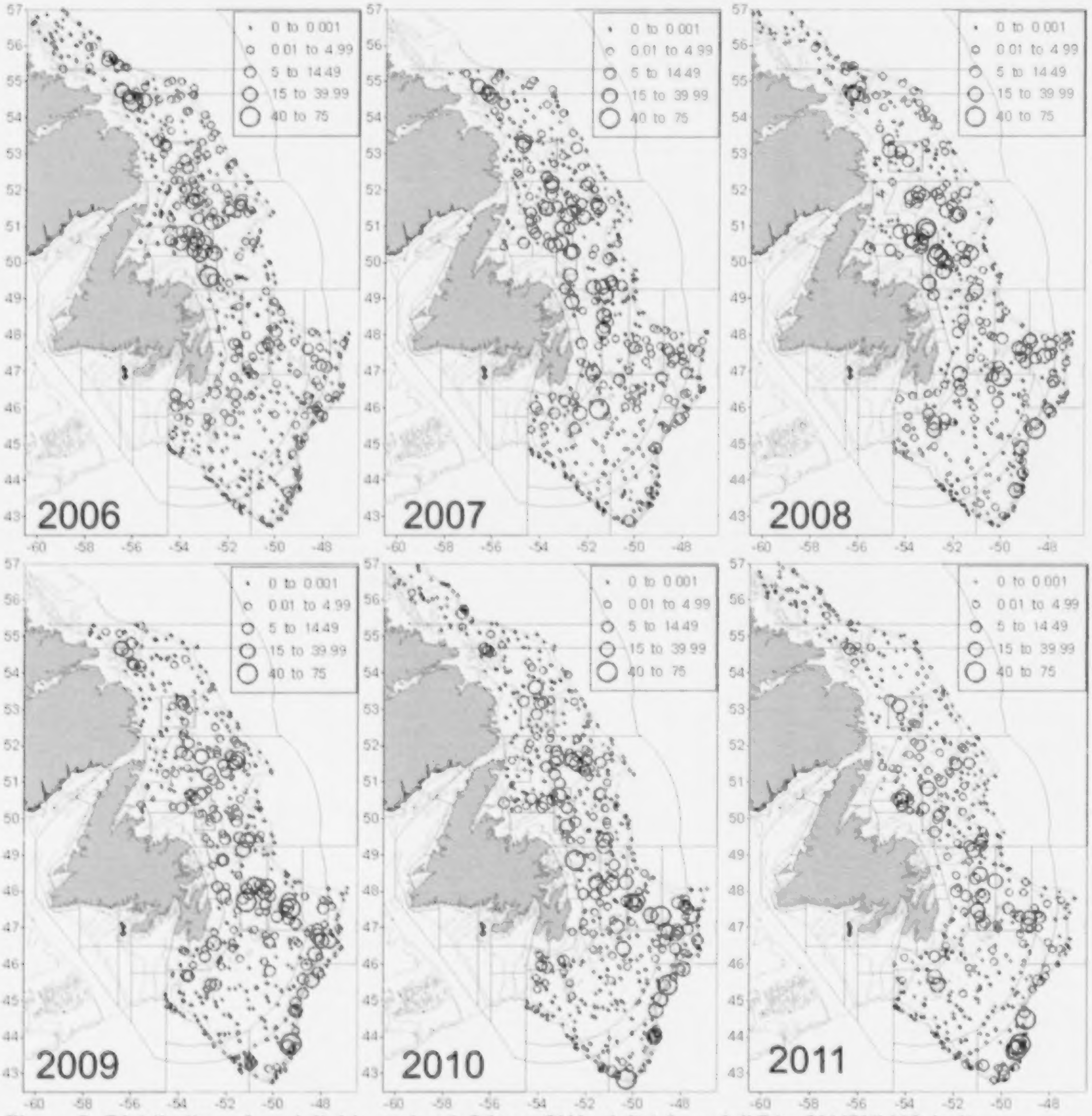

0 to 0.001
0.01 to 4.99
5 to 14.49
15 to 39.99
40 to 75
2006
2007
2008
2009
2010
2011
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43
-60
-58
-56
-54
-52
-50
-48

Figure 9: Distribution of exploitable males (>94mm CW adults) from fall Div. 2HJ3KLNO bottom trawl surveys from 2006 to 2011.

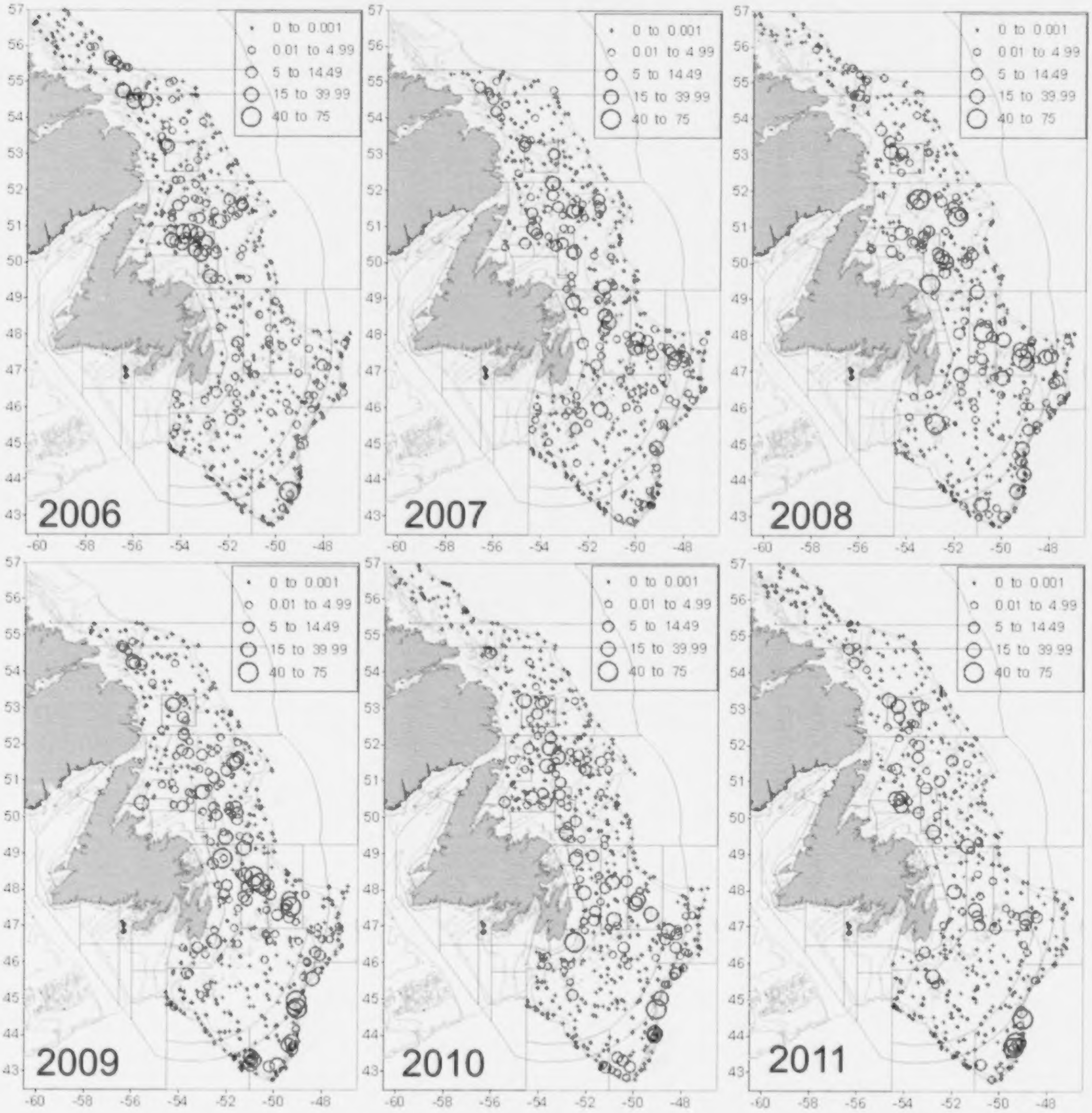

0 to 0.001
0.01 to 4.99
5 to 14.49
15 to 39.99
40 to 75
2006
2007
2008
2009
2010
2011
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43
-60
-58
-56
-54
-52
-50
-48

Figure 10: Distribution of pre-recruit males (>75mm CW adolescents) from fall Div. 2HJ3KLNO bottom trawl surveys from 2006 to 2011.

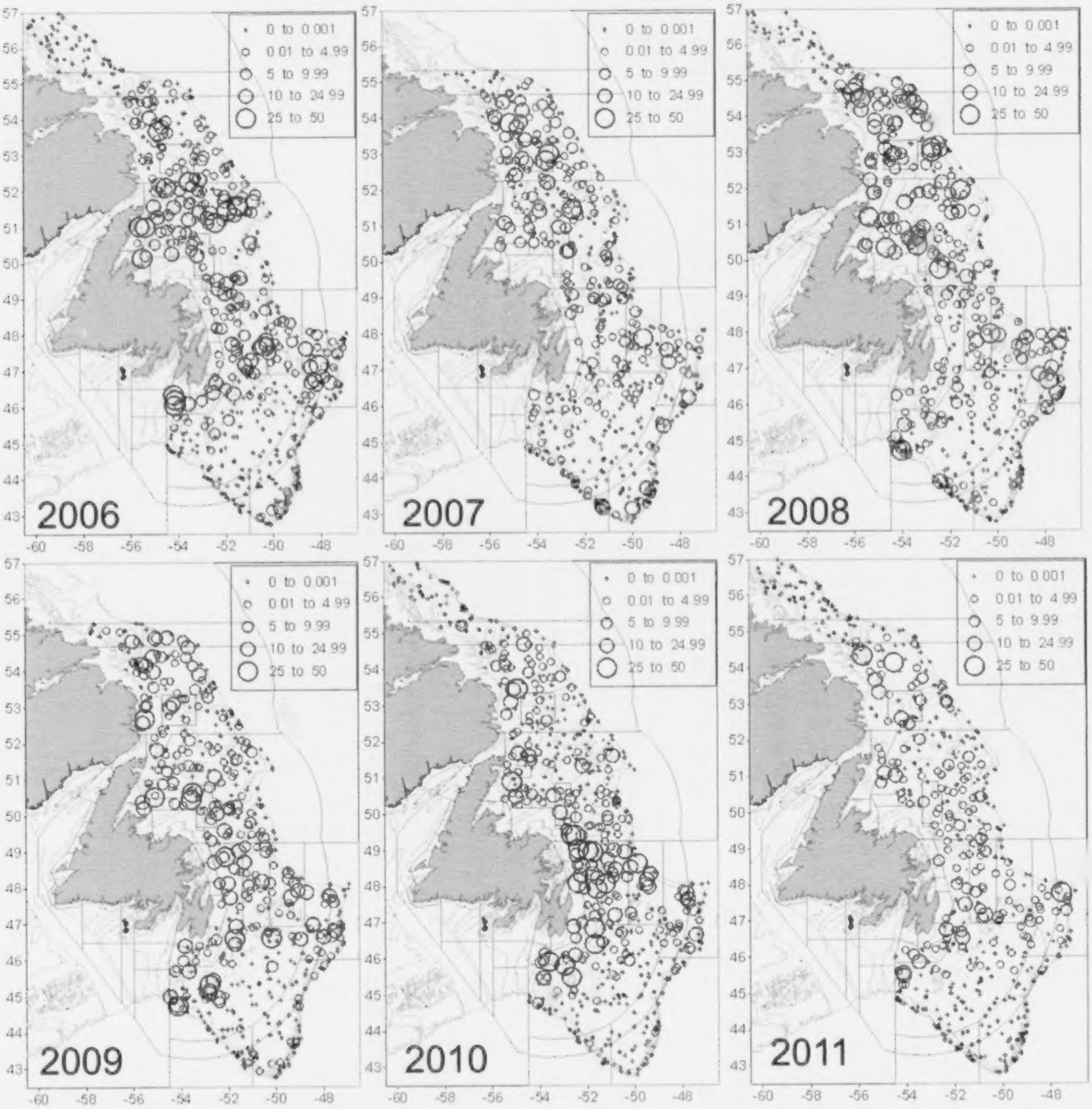

2006
2007
2008
2009
2010
2011
0 to 0.001
0.01 to 4.99
5 to 9.99
10 to 24.99
25 to 50
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43
-60
-58
-56
-54
-52
-50
-48

Figure 11: Distribution of small males (<60mm CW adolescents) from fall Div. 2HJ3KLNO bottom trawl surveys from 2006 to 2011.

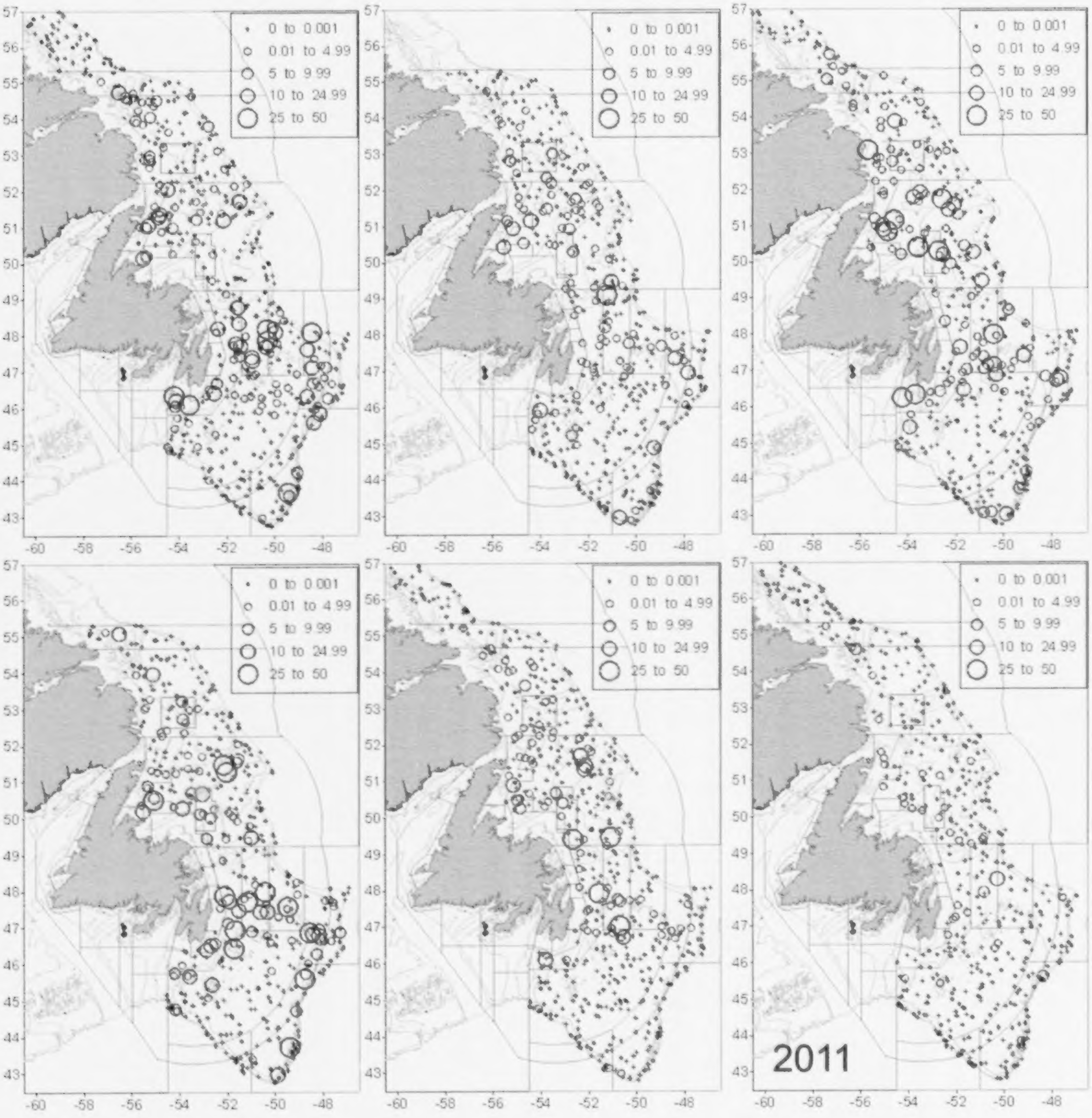

0 to 0.001
0.01 to 4.99
5 to 9.99
10 to 24.99
25 to 50
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43
-60
-58
-56
-54
-52
-50
-48
2011

Figure 12: Distribution of mature females from fall Div. 2HJ3KLNO bottom trawl surveys from 2006 to 2011.

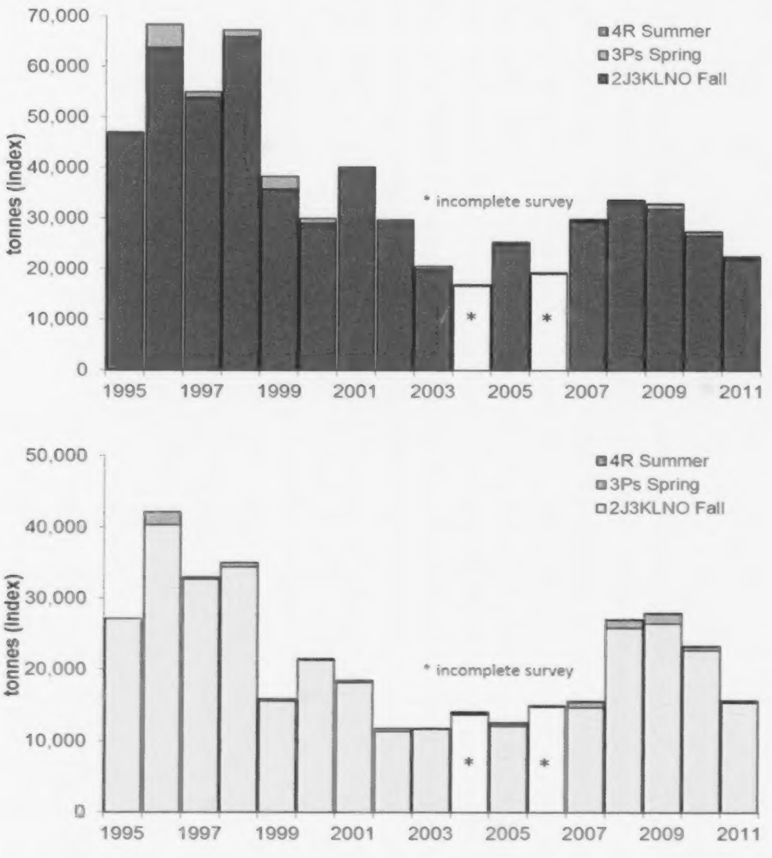


Figure 13: Trends in the trawl survey exploitable (above) and pre-recruit (below) biomass indices for Div. 2J3KLNO during fall, Subdiv. 3Ps during spring, and Div. 4R during summer. Note that season-specific indices are not additive due to differences in trawl efficiency.

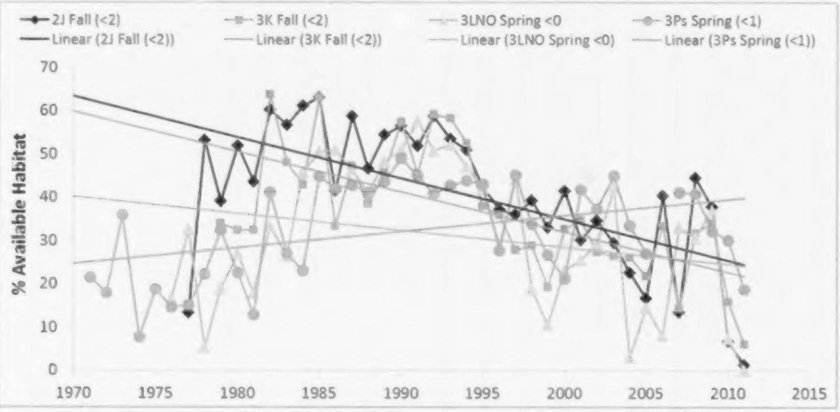


Figure 14: Snow crab thermal habitat index from fall trawl surveys.

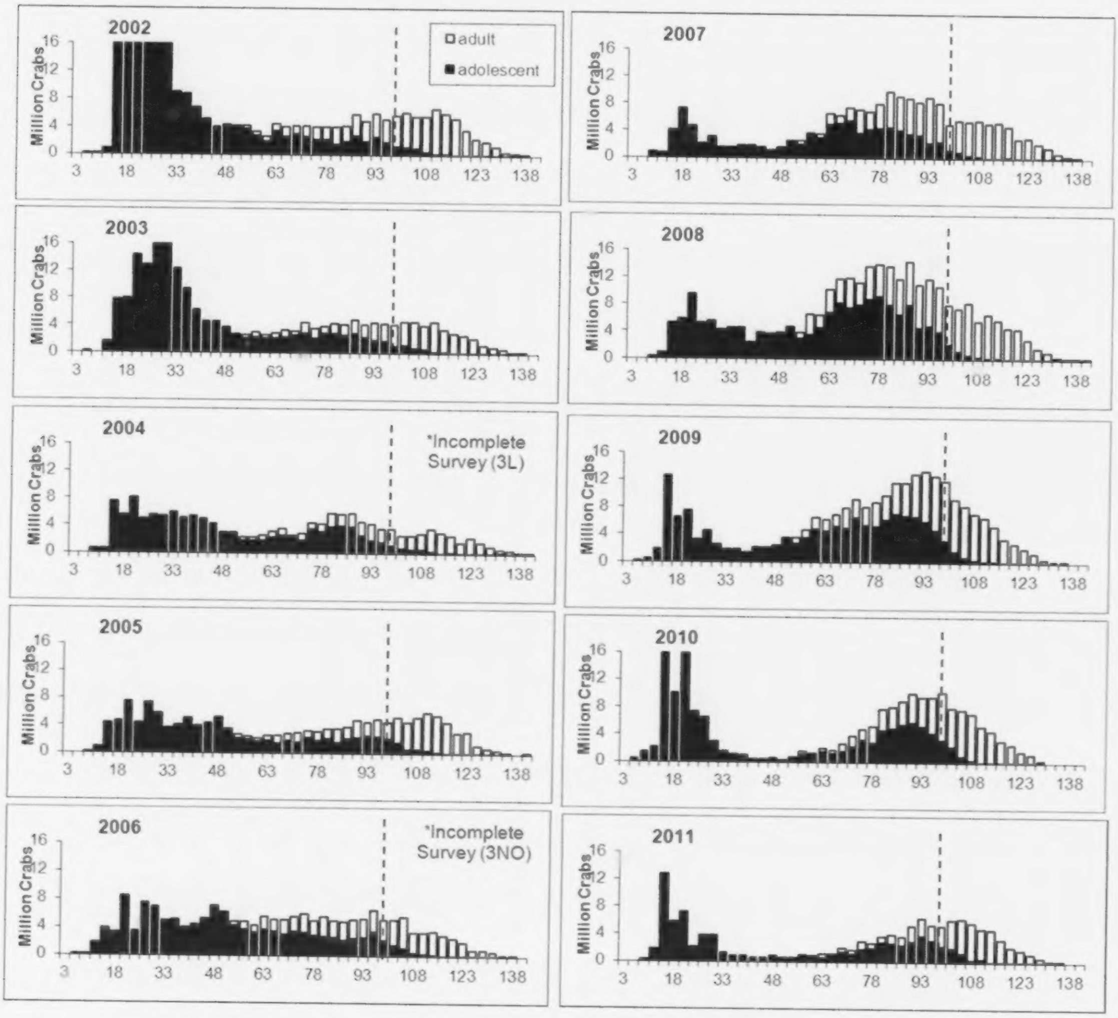


Figure 15: Abundance indices by carapace width for Div. 2J3KLNO juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line.

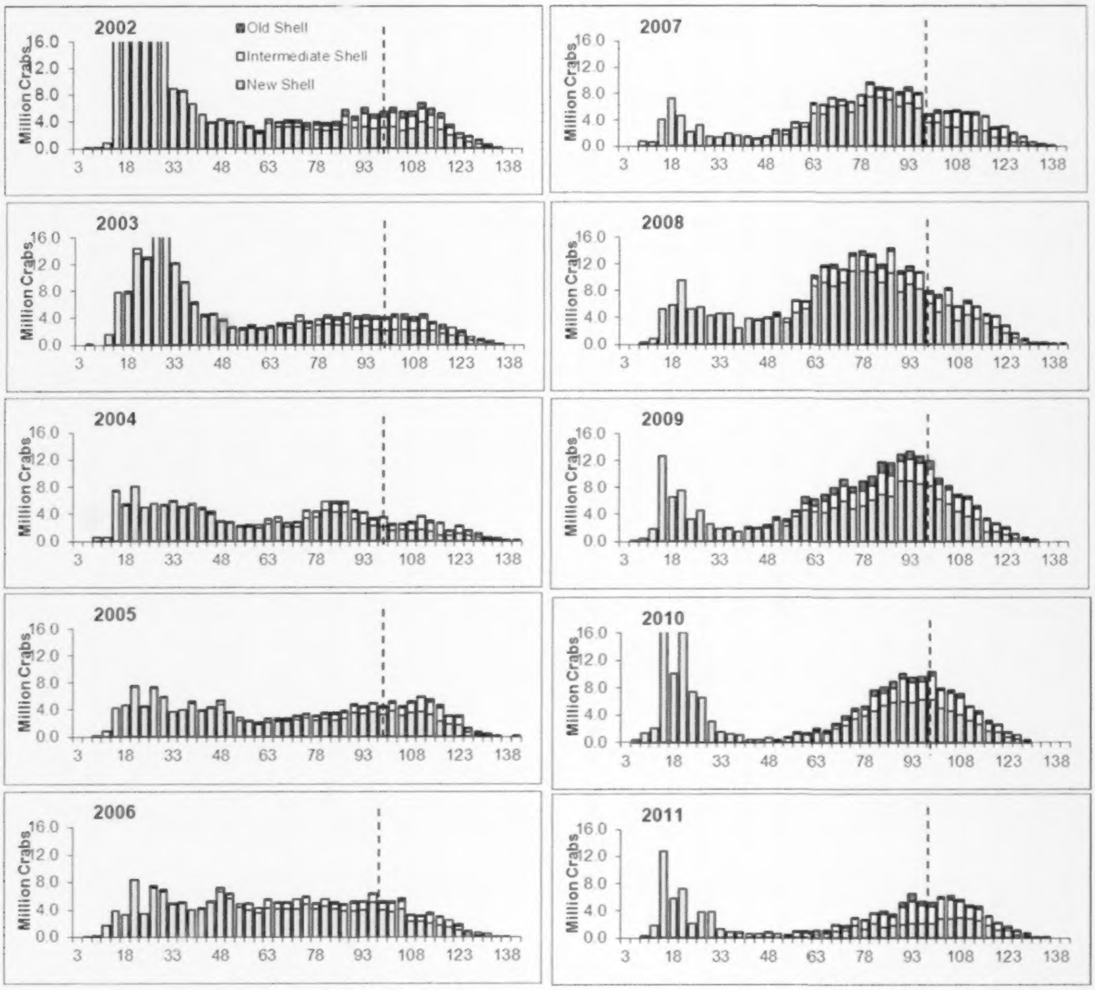


Figure 16: Abundance indices by carapace width and shell condition from fall trawl surveys for Div. 2J3KLNO. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line.

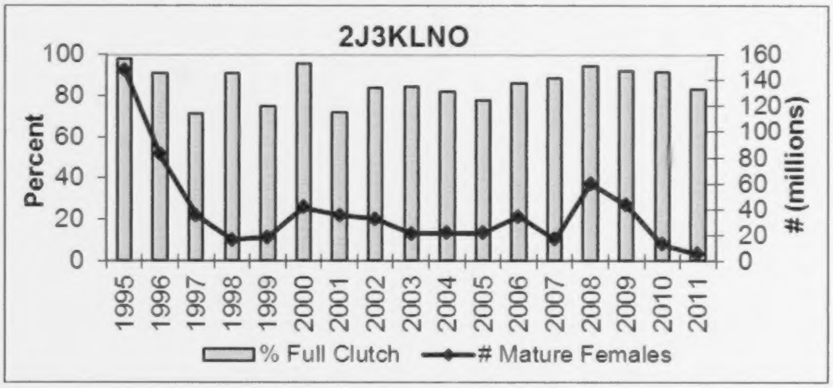


Figure 17: Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Div. 2J3KLNO from fall multi-species surveys.

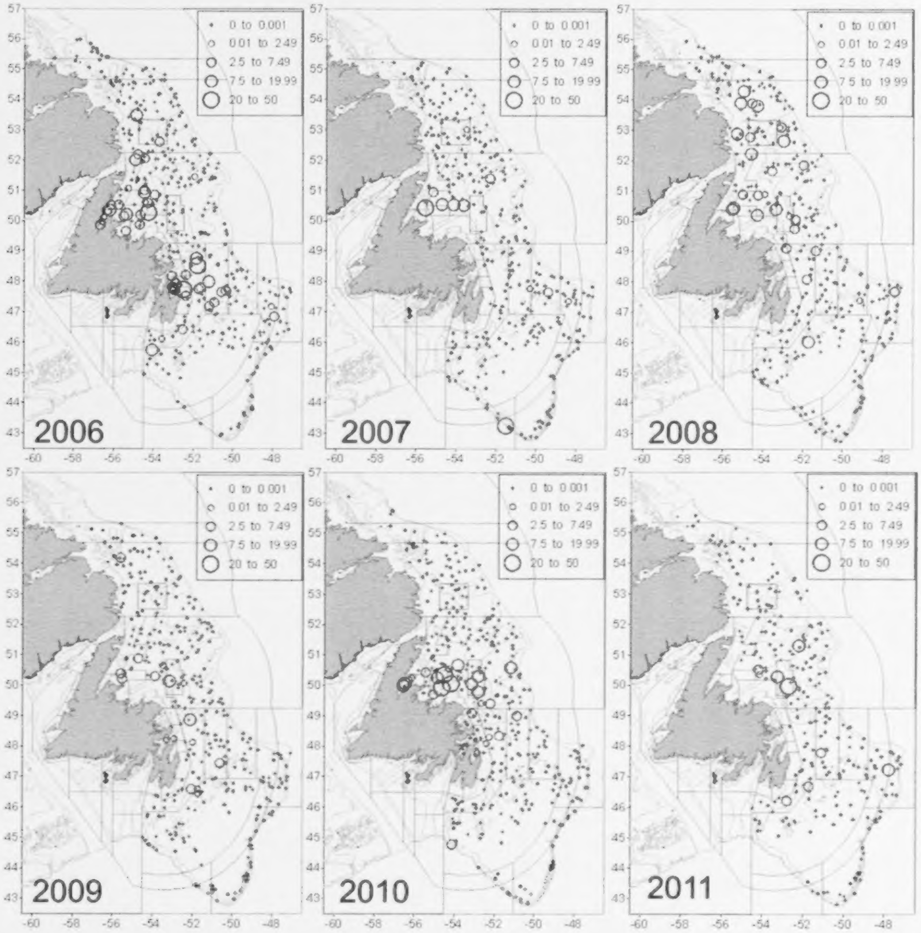

0 to 0.001
0.01 to 2.49
2.5 to 7.49
7.5 to 19.99
20 to 50
2006
2007
2008
2009
2010
2011
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43
-60
-58
-56
-54
-52
-50
-48

Figure 18: Percentage of fall trawl survey catches of male crabs with Bitter Crab Disease (BCD) from 2006 to 2011.

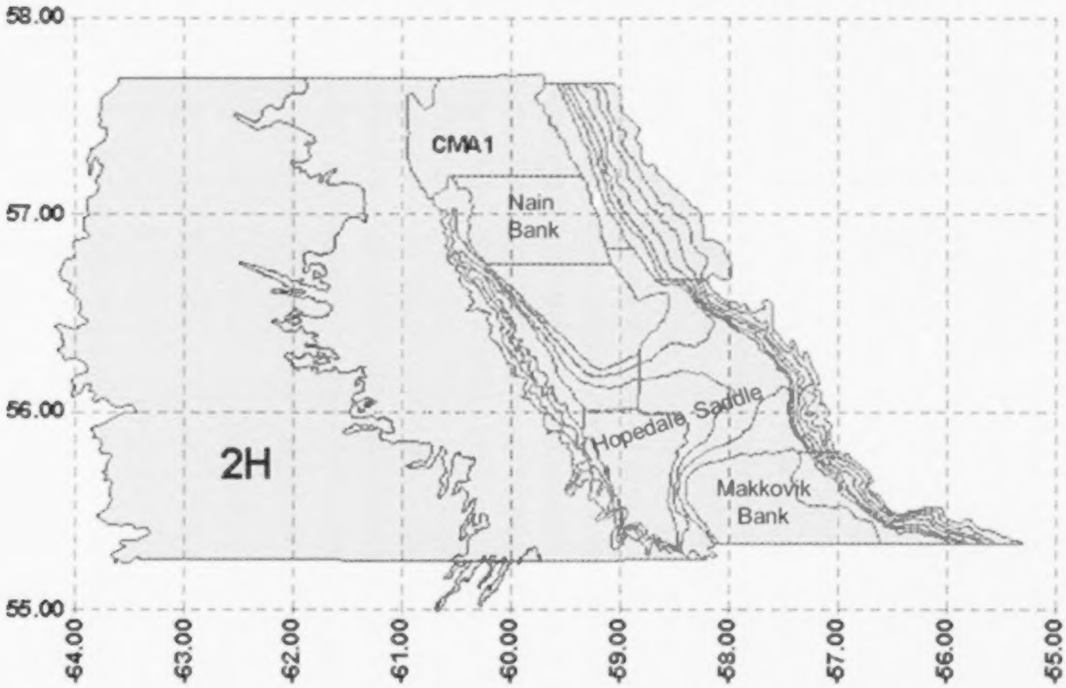

58.00
57.00
56.00
55.00
-64.00
-63.00
-62.00
-61.00
-60.00
-59.00
-58.00
-57.00
-56.00
-55.00
CMA1
Nain Bank
2H
Hopedale Saddle
Makkovik Bank

Figure 19: Map of Div. 2H showing important bathymetric features.

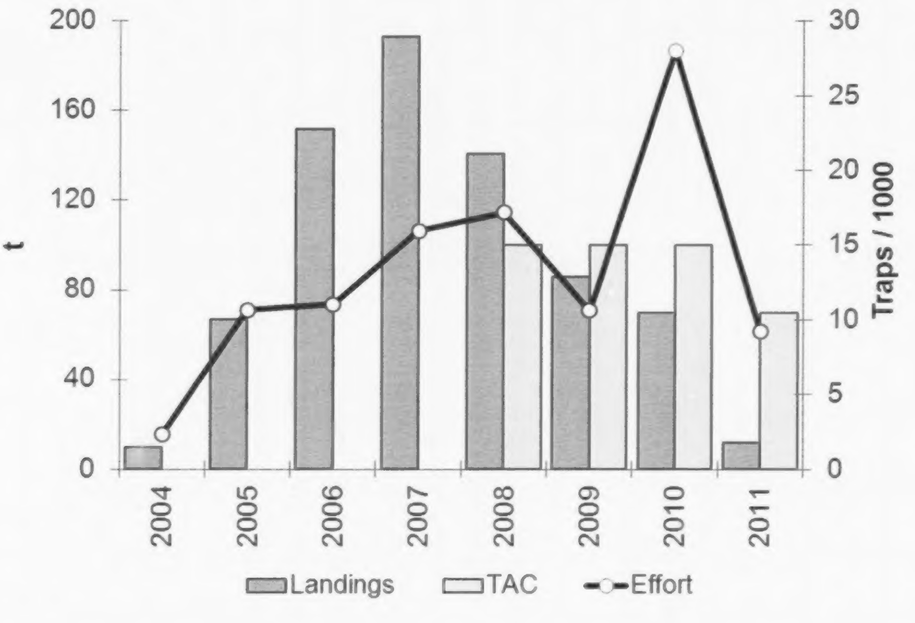


Figure 20: Trends in Div. 2H landings, total allowable catch (TAC), and fishing effort.

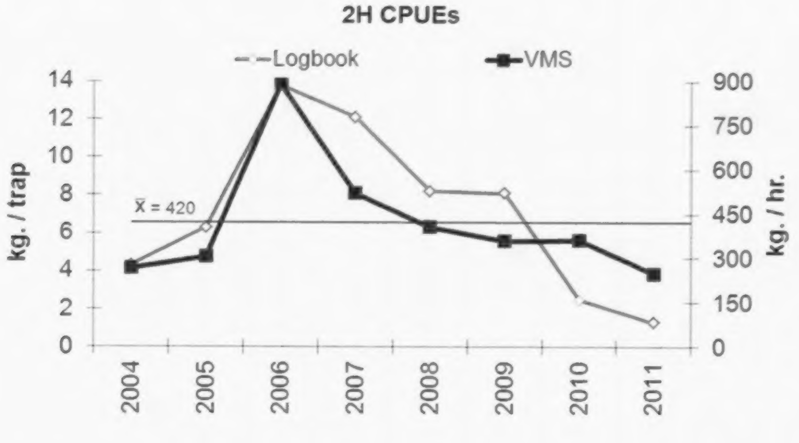


Figure 21: Trends in commercial logbook-based and Vessel Monitoring System (VMS)-based catch per unit effort (CPUE) in the Div. 2H fishery. Solid black line denotes long-term VMS CPUE average.

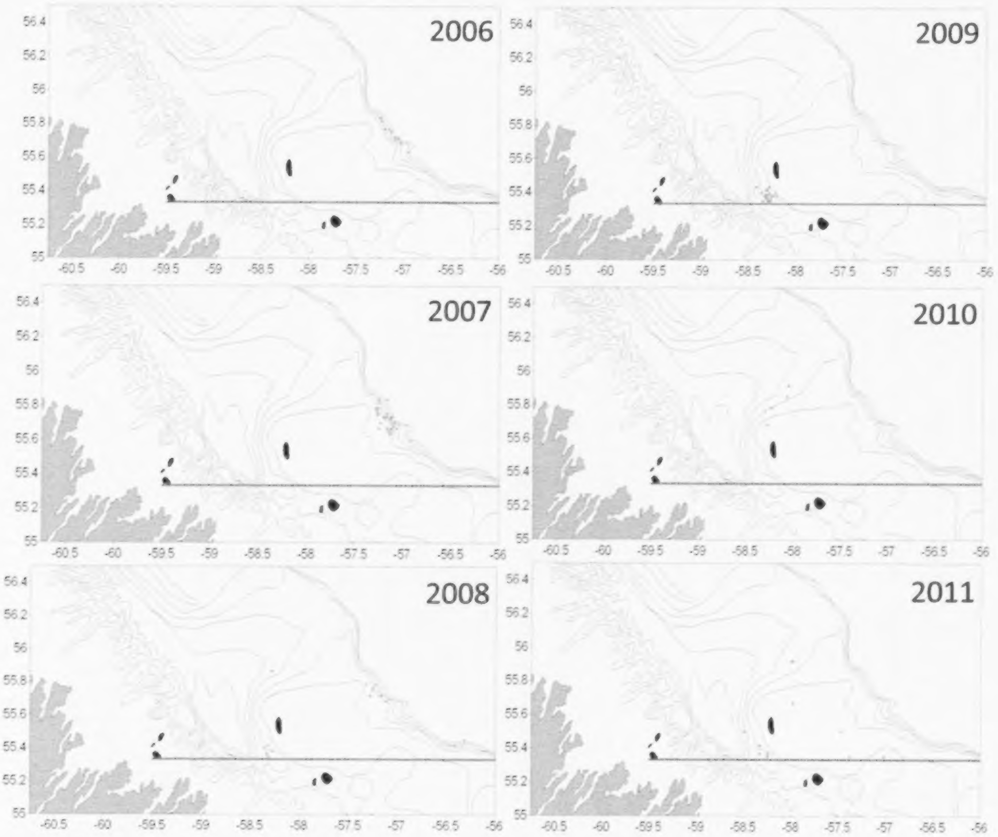

2006
2009
2007
2010
2008
2011
56.4
56.2
56
55.8
55.6
55.4
55.2
55
-60.5
-60
-59.5
-59
-58.5
-58
-57.5
-57
-56.5
-56

Figure 22: Spatial distribution of Div. 2H fishing effort from 2006 to 2011.

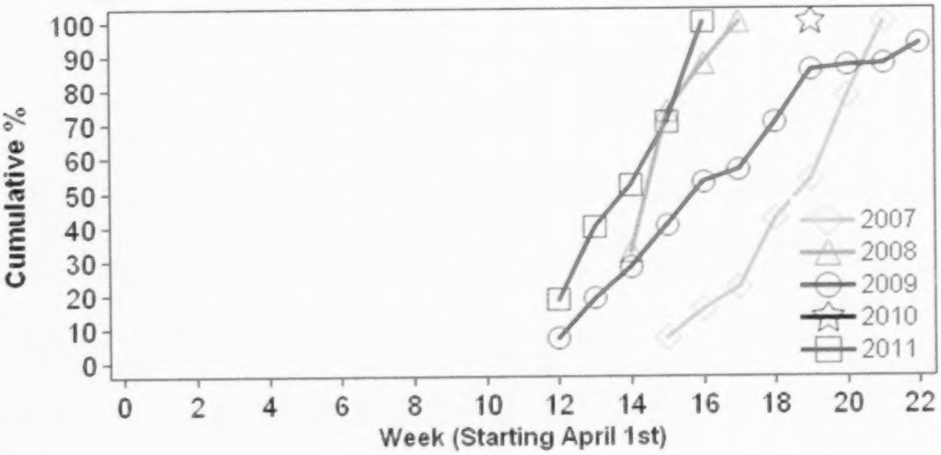


Figure 23: Seasonal trends in weekly fishing effort for Div. 2H during 2007-2011.

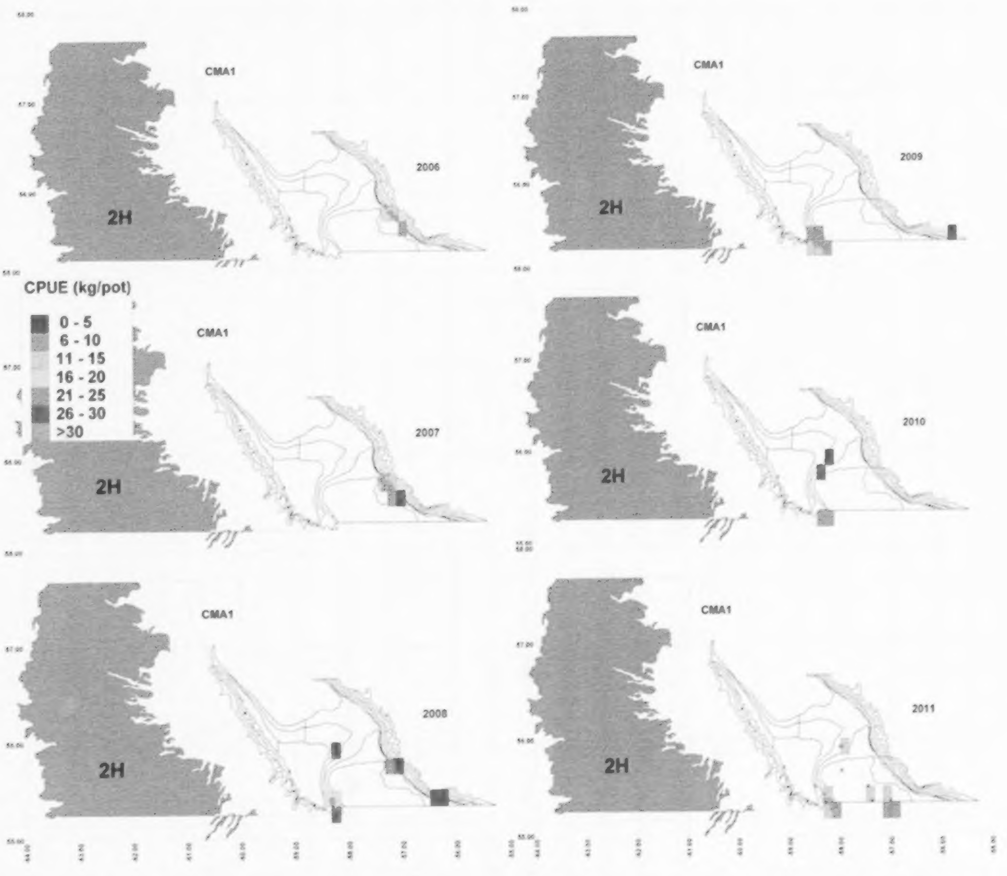

CMA1
2006
2H
CMA1
2009
2H
CPUE (kg/pot)
0 - 5
6 - 10
11 - 15
16 - 20
21 - 25
26 - 30
>30
CMA1
2007
2H
CMA1
2010
2H
CMA1
2008
2H
CMA1
2011
2H

Figure 24: Spatial distribution of Div. 2H commercial catch per unit effort (CPUE) from 2006 to 2011.

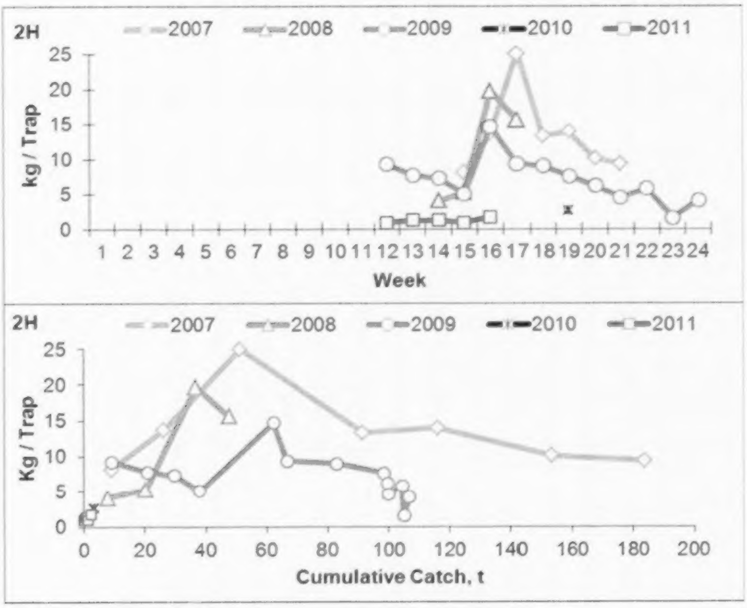


Figure 25: Seasonal trends in logbook catch per unit effort (CPUE) for Div. 2H during 2007-2011; by week (above), and in relation to cumulative catch (below).

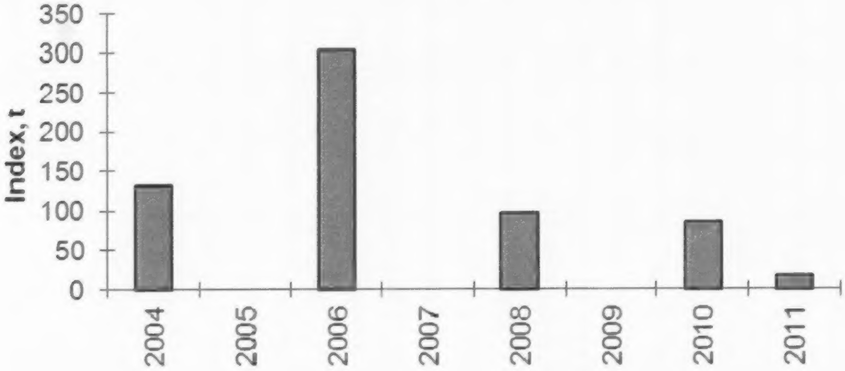


Figure 26: Trends in the Div. 2H fall trawl survey exploitable biomass index.

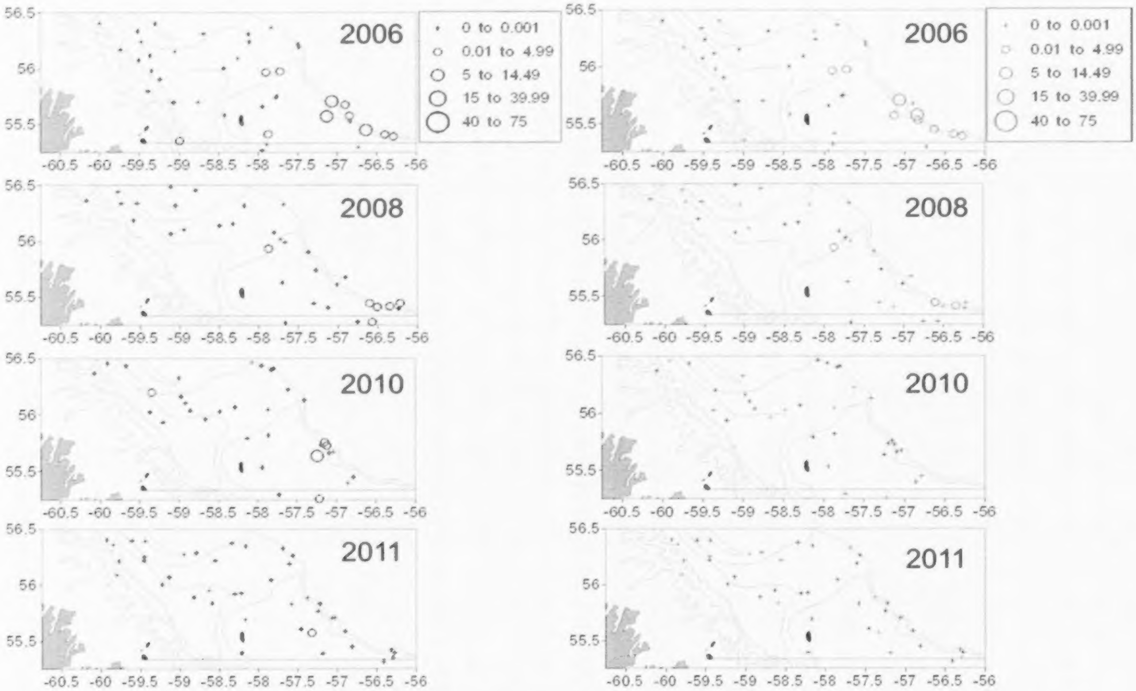

2006
2008
2010
2011
0 to 0.001
0.01 to 4.99
5 to 14.49
15 to 39.99
40 to 75
56.5
56
55.5
-60.5 -60 -59.5 -59 -58.5 -58 -57.5 -57 -56.5 -56

Figure 27: Spatial distribution of catches (number/set) of exploitable (left) and pre-recruit (right) males in the Div. 2H fall trawl survey from 2006 to 2011

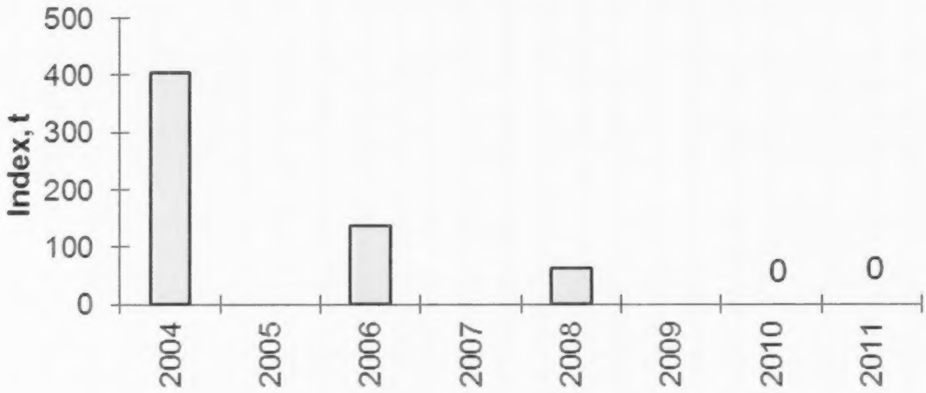


Figure 28: Trends in the Div. 2H fall trawl survey pre-recruit biomass index.

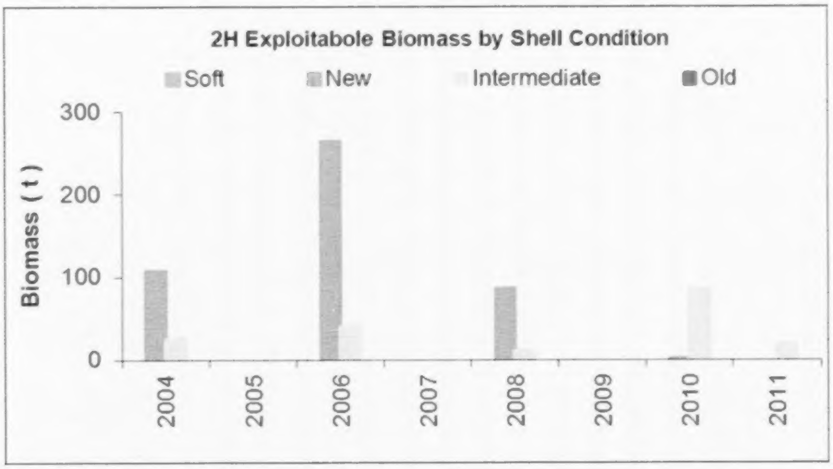


Figure 29: Trends, by shell condition, in legal-sized males for Div. 2H from fall trawl surveys

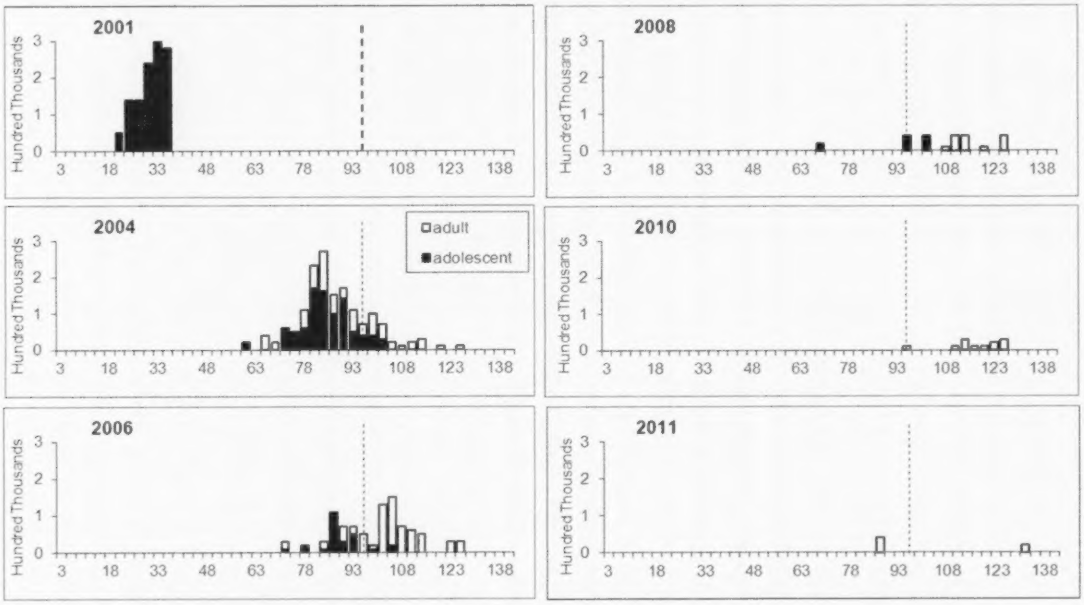


Figure 30: Abundance indices by carapace width for Div. 2H juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line.

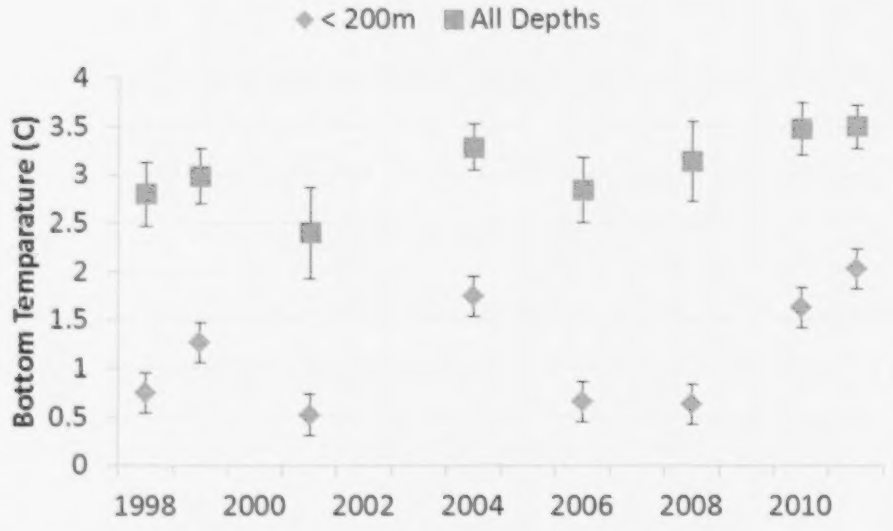


Figure 31: Trends in bottom temperature from the Div. 2H fall trawl surveys.

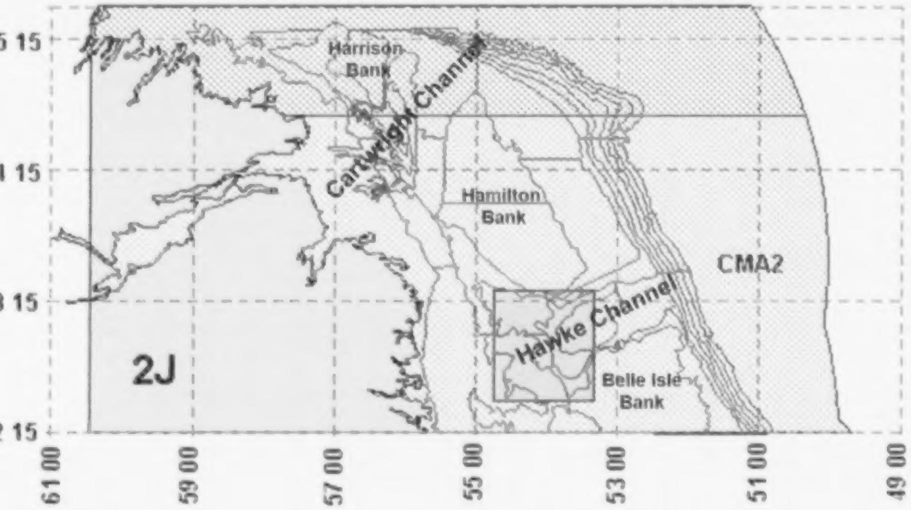

55 15
54 15
53 15
52 15
61 00
59 00
57 00
55 00
53 00
51 00
49 00
Harrison Bank
Cartwright Channel
Hamilton Bank
CMA2
Hawke Channel
Belle Isle Bank
2J

Figure 32: Map of Div. 2J showing important bathymetric features and the Hawke Channel closed area.

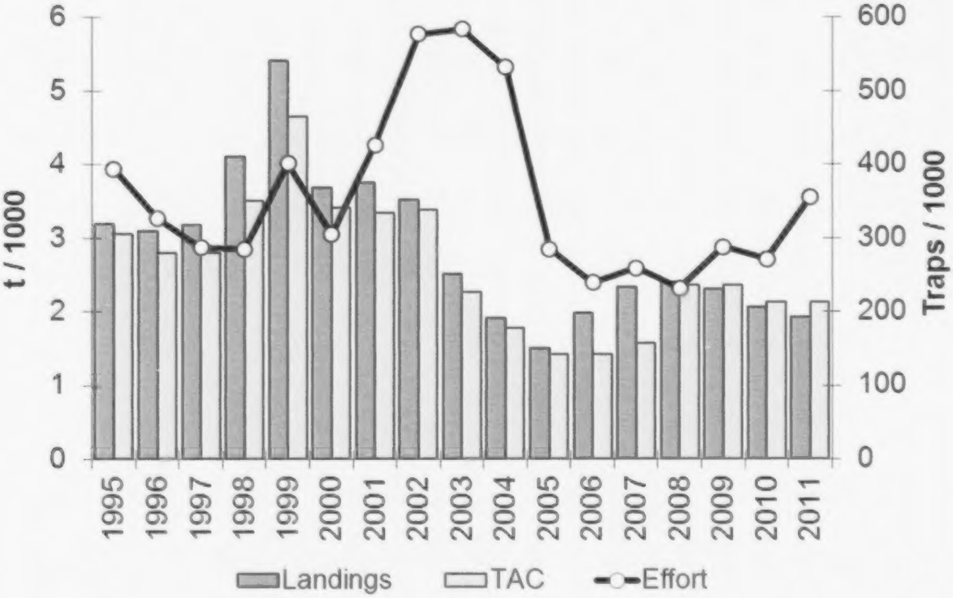


Figure 33: Trends in Div. 2J landings, total allowable catch (TAC), and fishing effort.

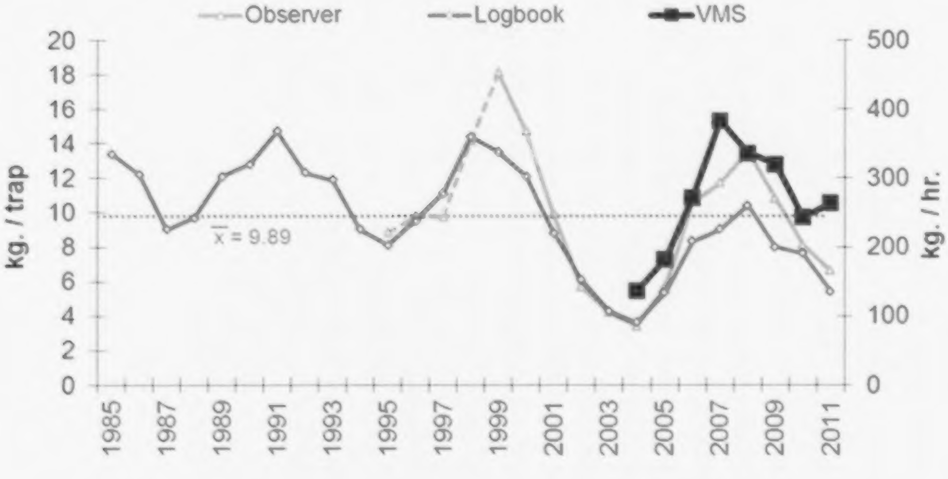


Figure 34: Trends in commercial logbook-based, observer-based, and Vessel Monitoring System (VMS)-based catch per unit effort (CPUE) in the Div. 2J fishery. Solid blue line denotes long-term logbook CPUE average.

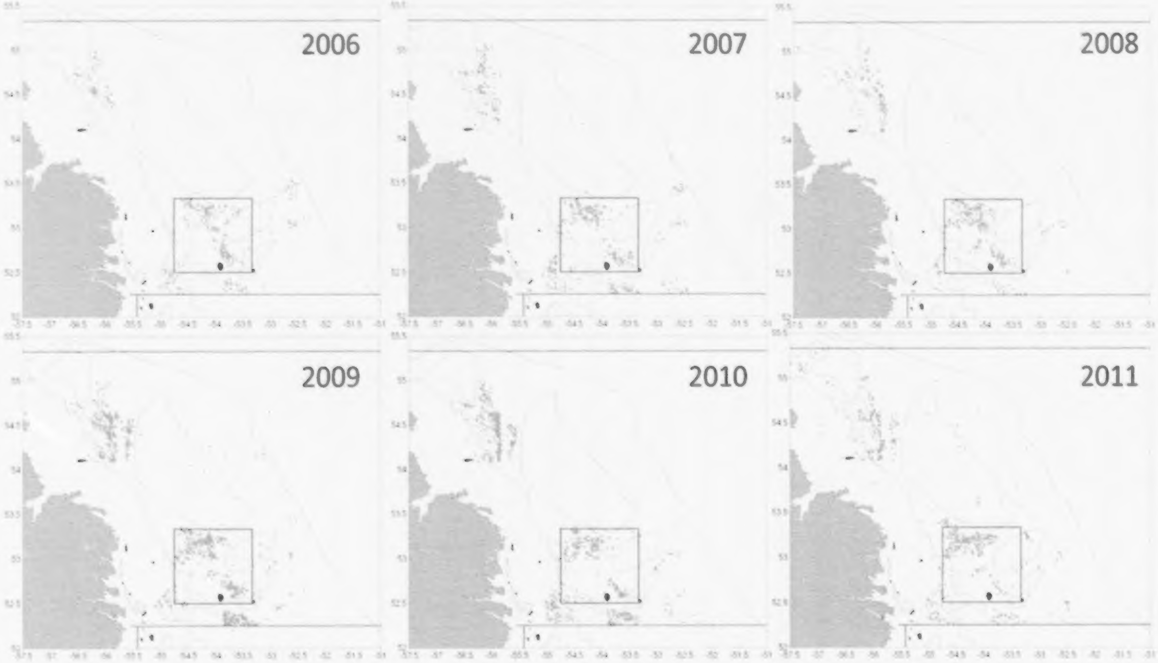

2006
2007
2008
2009
2010
2011

Figure 35: Spatial distribution of Div. 2J fishing effort by year from 2006 to 2011.

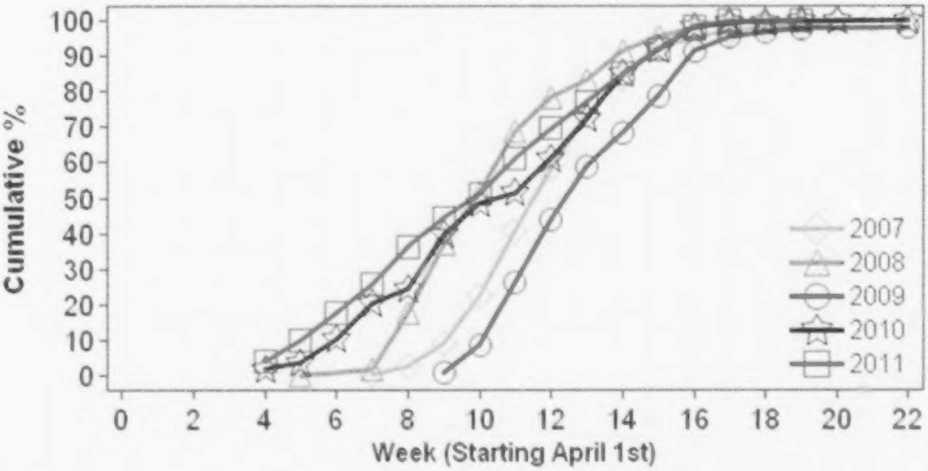


Figure 36: Seasonal trends in weekly fishing effort for Div. 2J during 2007-2011.

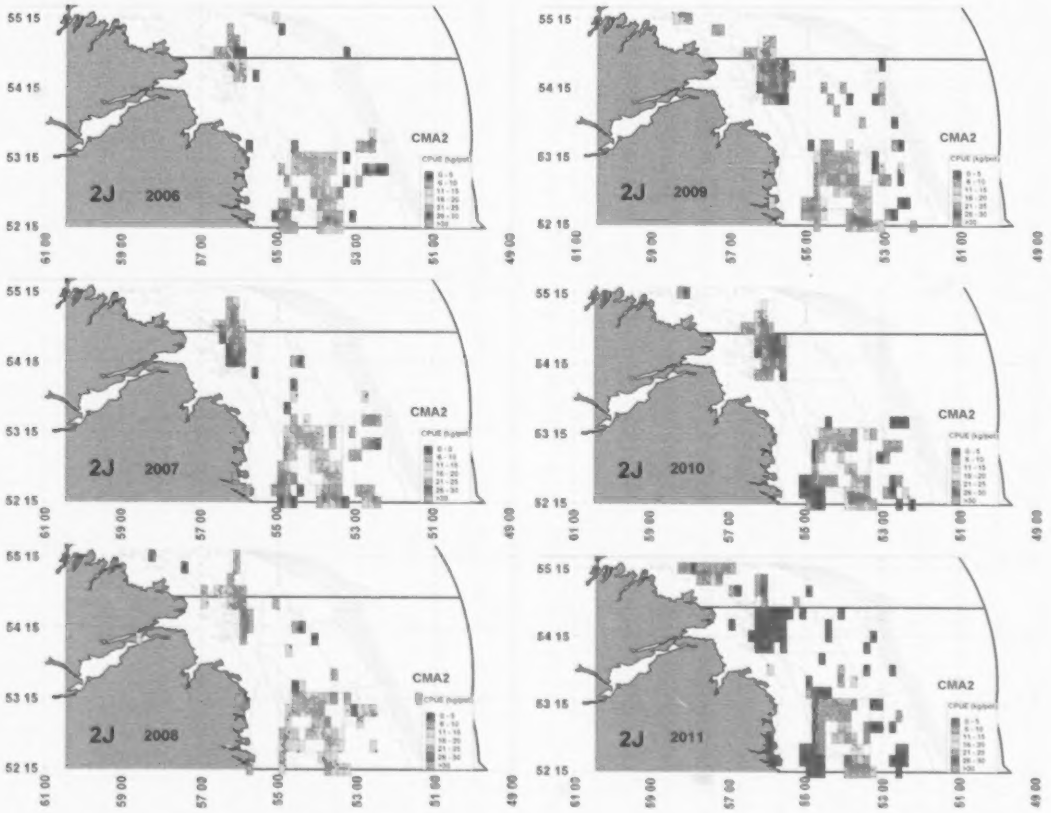

55 15
54 15
53 15
52 15
61 00
59 00
57 00
55 00
53 00
51 00
49 00
CMA2
CPUE (kg/pot)
0 - 5
6 - 10
11 - 15
16 - 20
21 - 25
26 - 30
>30
2J 2006
2J 2009
2J 2007
2J 2010
2J 2008
2J 2011

Figure 37: Spatial distribution of Div. 2J logbook catch per unit effort (CPUE) from 2007 to 2011.

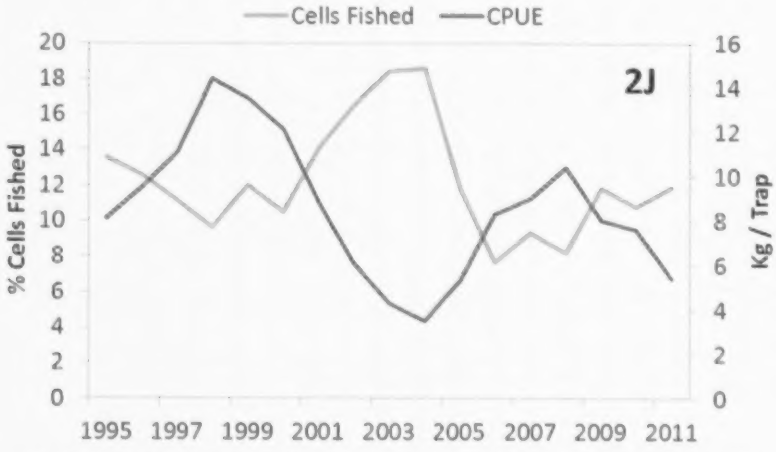


Figure 38: Trends in Div. 2J commercial catch per unit effort (CPUE) vs. the percentage of 5' x 5' cells fished.

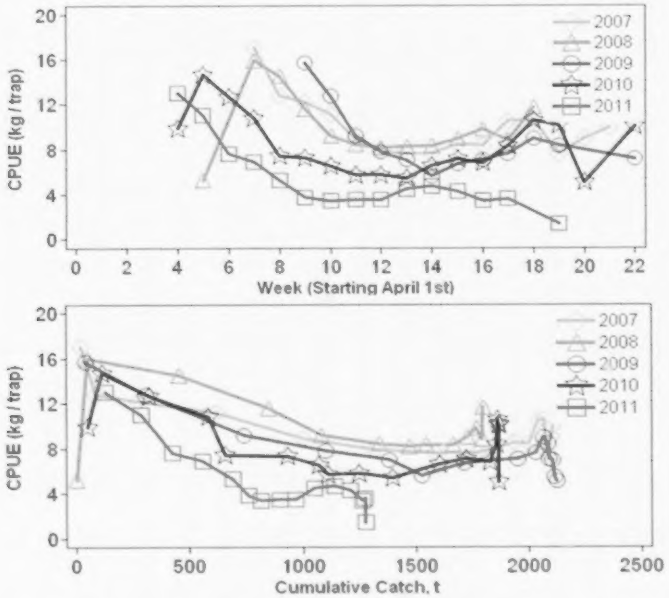


Figure 39: Seasonal trends in logbook catch per unit effort (CPUE) for Div. 2J during 2007-2011; by week (above), and in relation to cumulative catch (below).

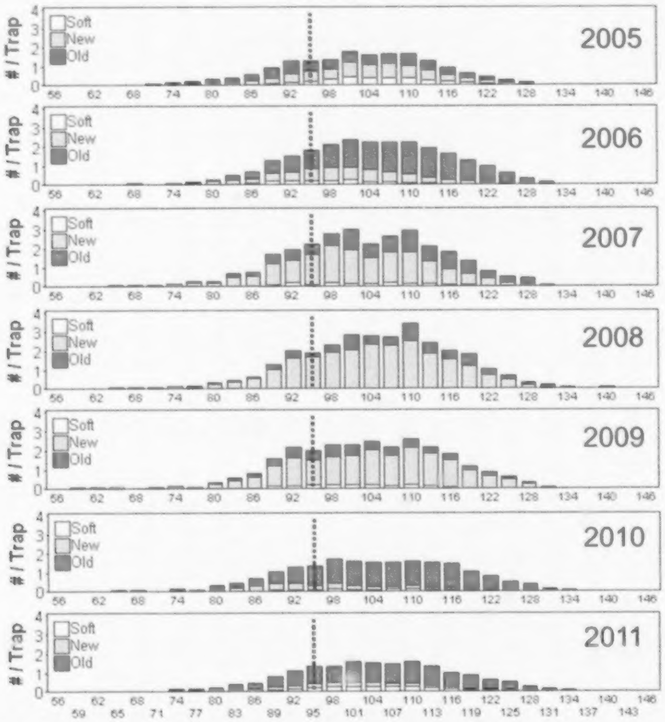


Figure 40: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Div. 2J. The vertical dashed line indicates the minimum legal size.

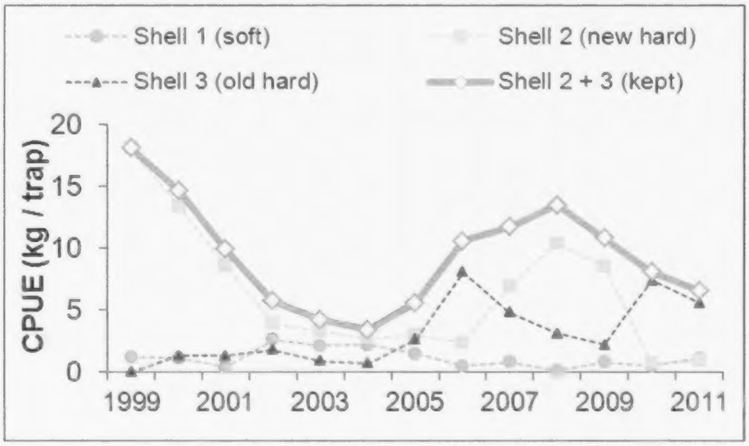


Figure 41: Trends in Div. 2J observer catch rates of legal-sized crabs by shell condition from at-sea sampling.

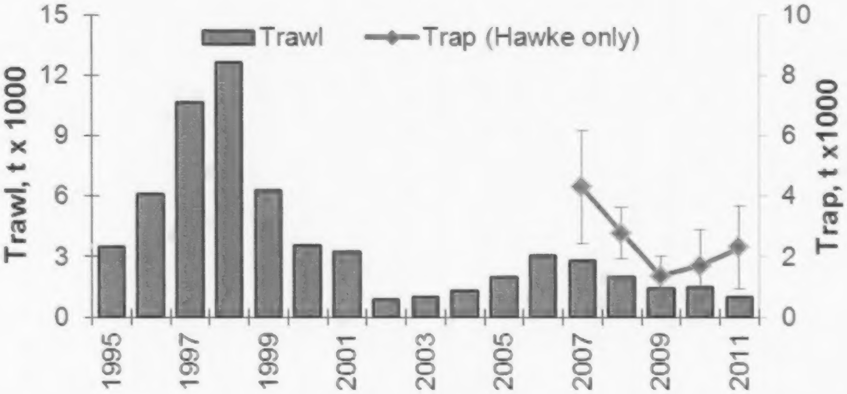


Figure 42: Trends in the Div. 2J fall trawl survey exploitable biomass index and the Collaborative Post-Season (CPS) trap survey exploitable biomass index.

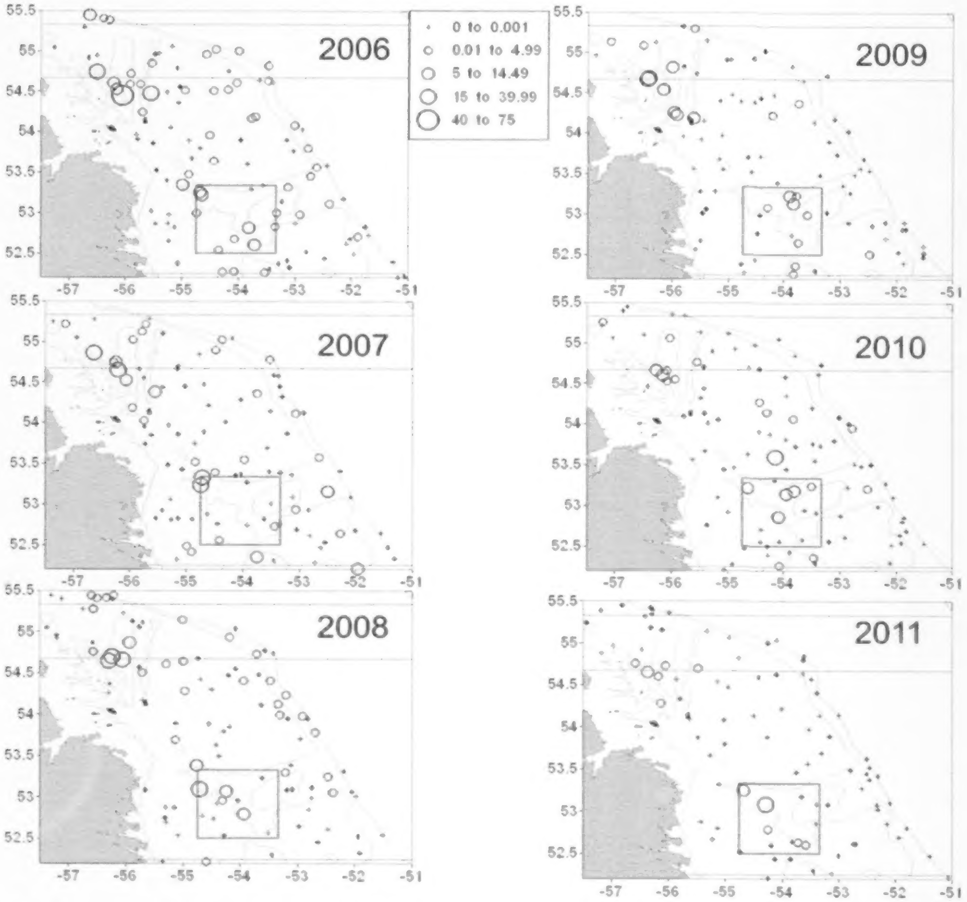

2006
2007
2008
2009
2010
2011
0 to 0.001
0.01 to 4.99
5 to 14.49
15 to 39.99
40 to 75
55.5
55
54.5
54
53.5
53
52.5
-57
-56
-55
-54
-53
-52
-51

Figure 43: Spatial distribution of catches (number / set) of exploitable males in the Div. 2J fall trawl survey from 2006 to 2011.

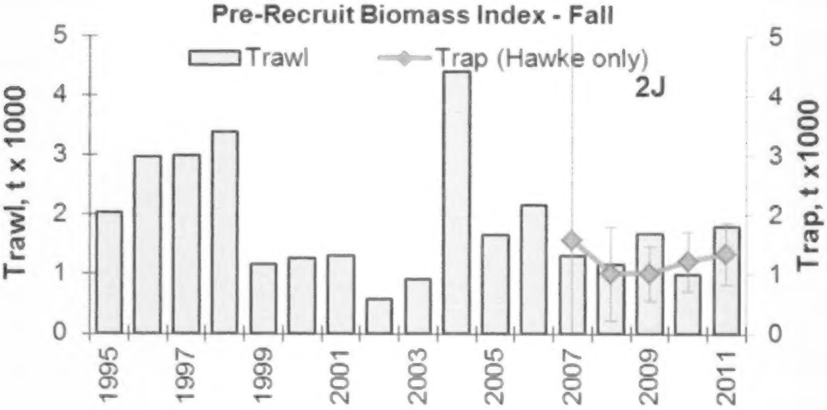


Figure 44: Trends in the Div. 2J fall trawl survey pre-recruit biomass index and the Collaborative Post-Season (CPS) trap survey pre-recruit biomass index.

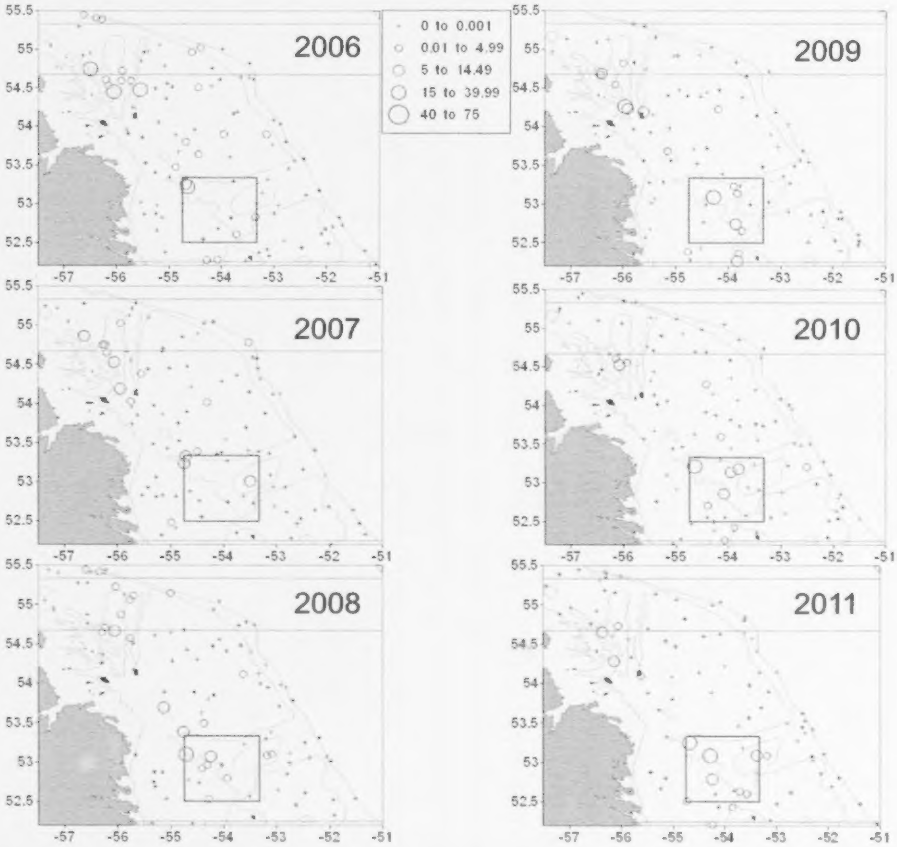

2006
2007
2008
2009
2010
2011
0 to 0.001
0.01 to 4.99
5 to 14.49
15 to 39.99
40 to 75
55.5
55
54.5
54
53.5
53
52.5
-57
-56
-55
-54
-53
-52
-51

Figure 45: Spatial distribution of catches (number / set) of pre-recruit males in the Div. 2J fall trawl survey from 2006 to 2011.

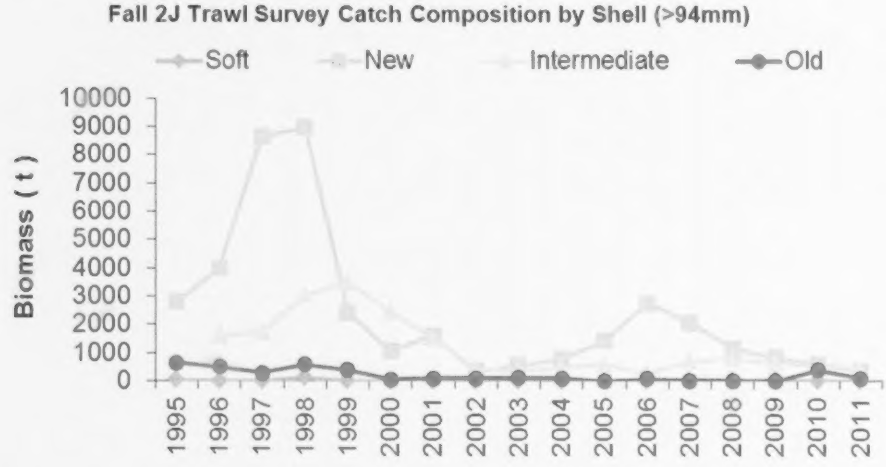


Figure 46: Trends, by shell condition, in biomass of legal-sized males for Div. 2J from fall trawl surveys.

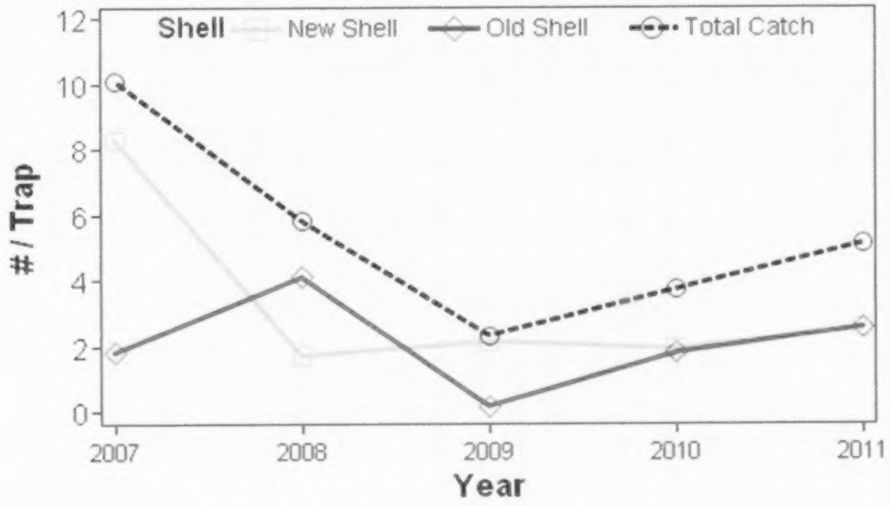


Figure 47: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Div. 2J Collaborative Post-Season (CPS) trap survey.

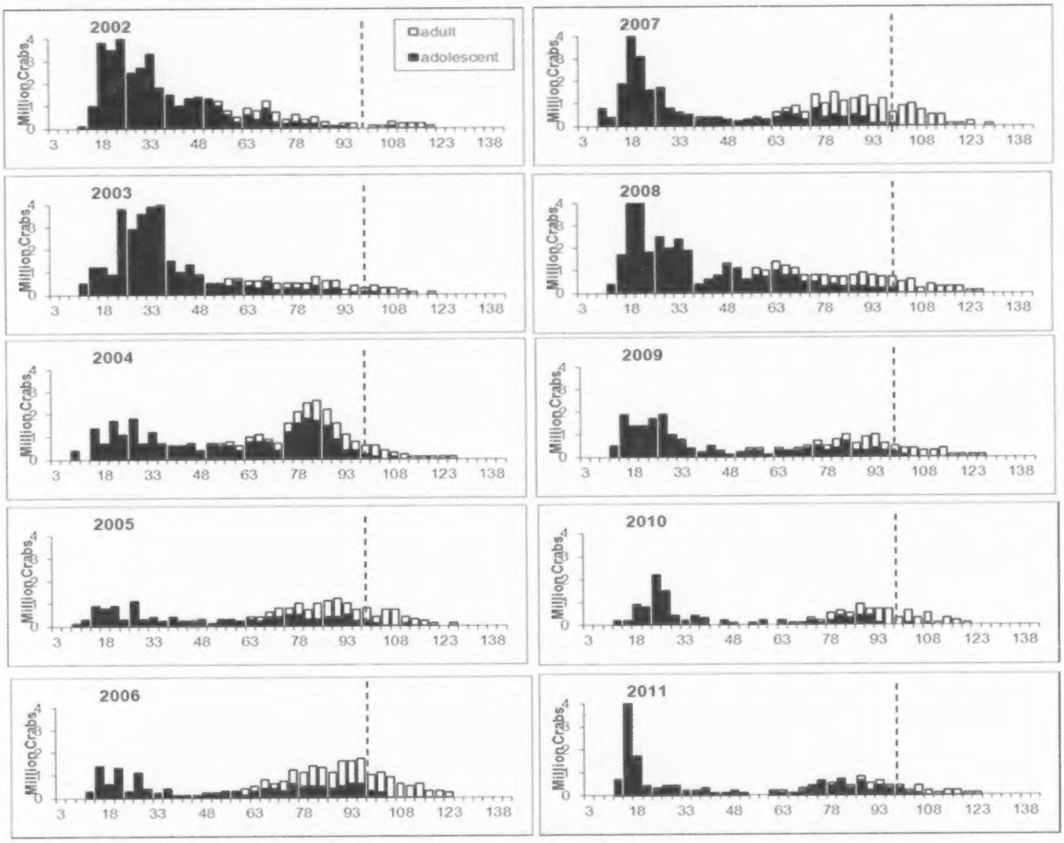


Figure 48: Abundance indices by carapace width for Div. 2J juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys.

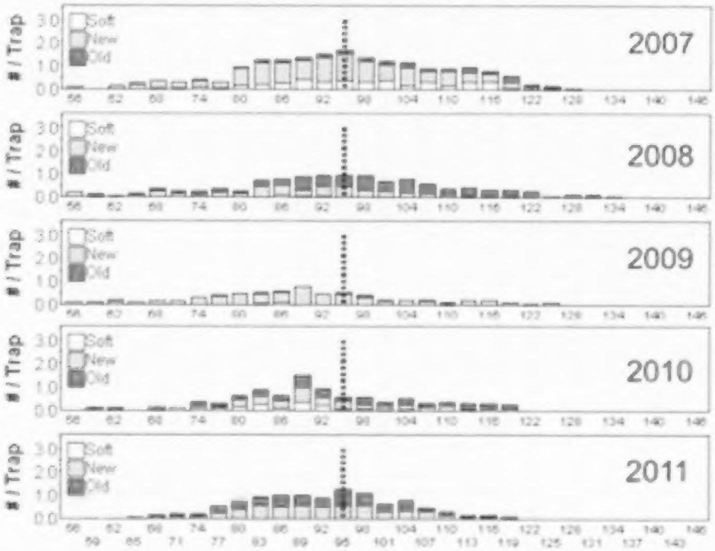


Figure 49: Trends in male carapace width distributions from core stations in the Div. 2J Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

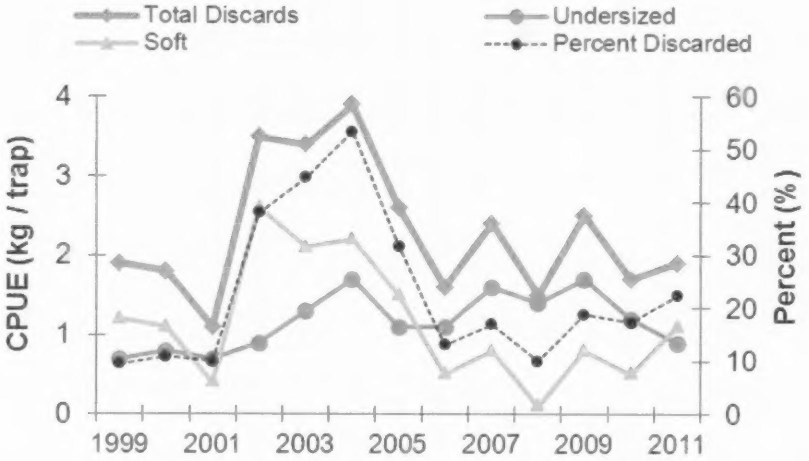
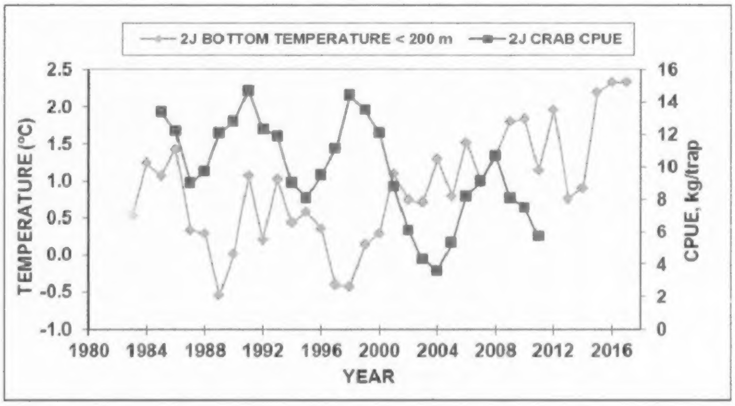


Figure 50: Trends in Div. 2J observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.



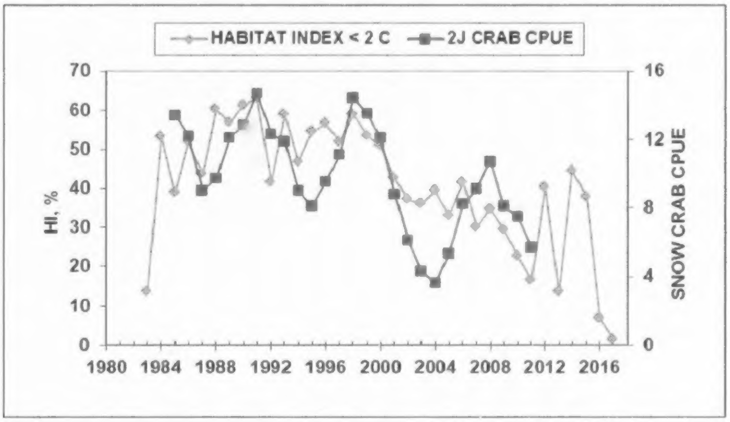


Figure 51: Trends in the Div. 2J catch per unit effort (CPUE) vs. bottom temperature (above) and the spatial extent of <2 degree water (below) at a six year lag.

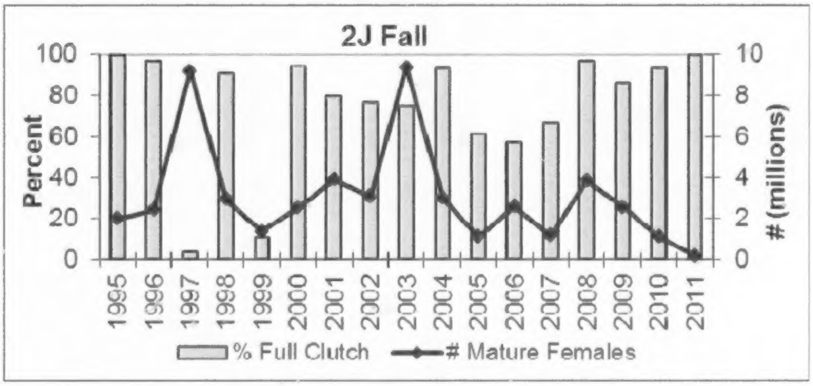


Figure 52: Trends in mature female abundance and percentage bearing full clutches of viable eggs in Div. 2J from fall multi-species surveys.

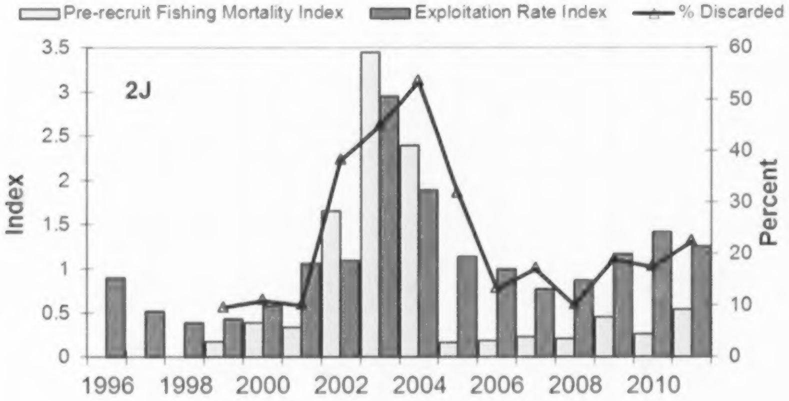


Figure 53: Trends in Div. 2J mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery.

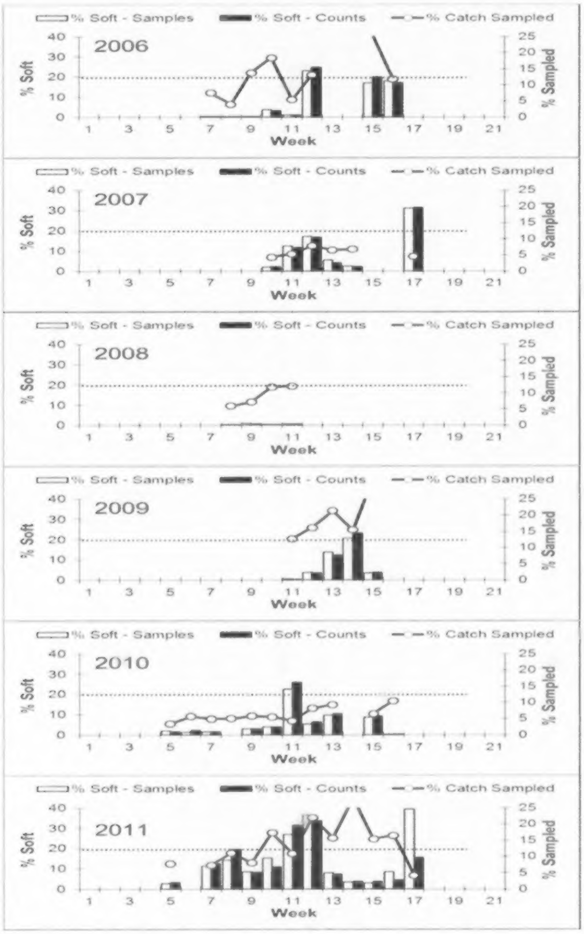


Figure 54: Trends in weekly percentages of soft-shell crab monitored and sampled in Div. 2J from 2006 to 2011.

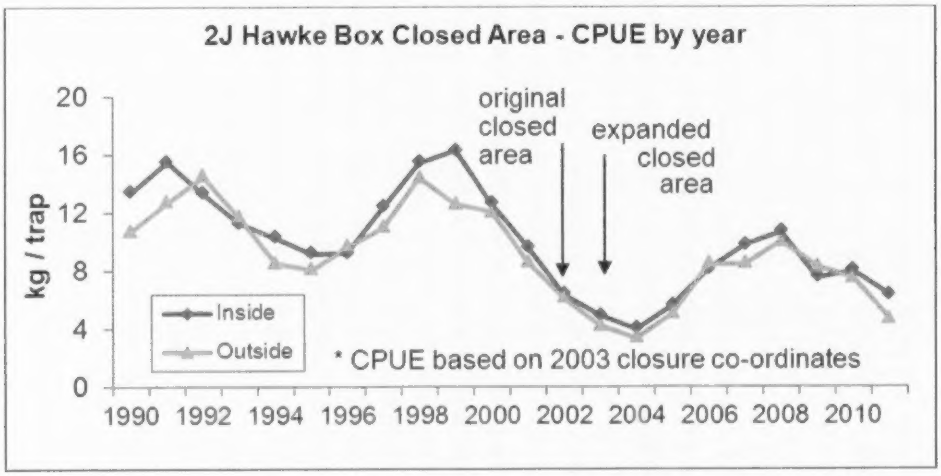


Figure 55: Div. 2J commercial catch per unit effort (CPUE); inside vs. outside the Hawke Channel closed area.

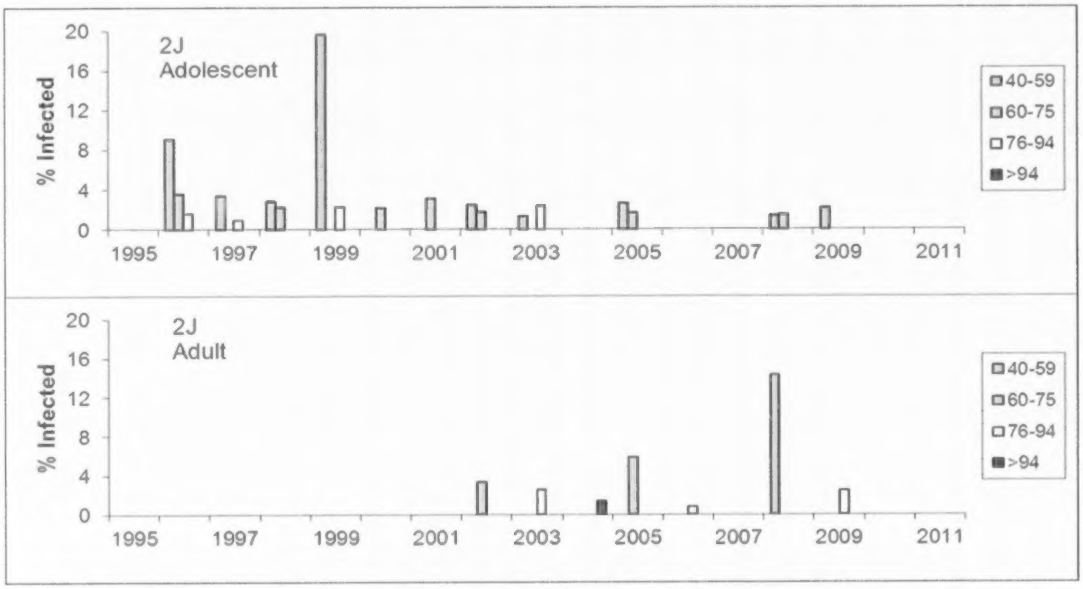


Figure 56: Trends in prevalence of Bitter Crab Disease (BCD) in new-shelled adolescents (above) and adults (below) by male size group from Div. 2J fall trawl surveys.

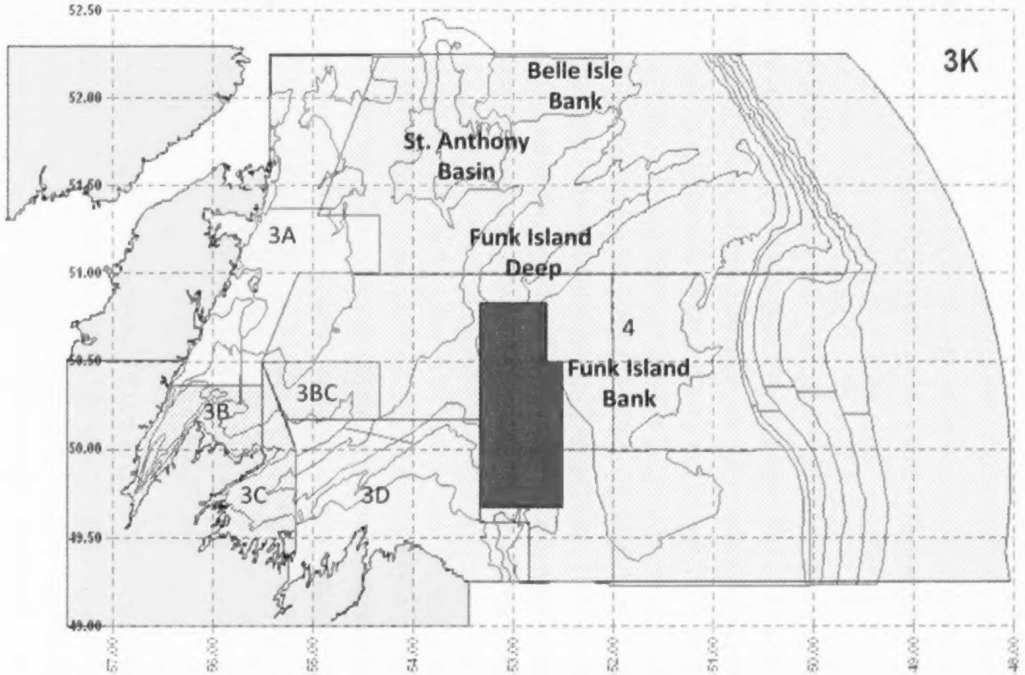

3K
Belle Isle Bank
St. Anthony Basin
3A
Funk Island Deep
4
Funk Island Bank
3BC
3B
3C
3D
52.50
52.00
51.50
51.00
50.50
50.00
49.50
49.00
-57.00
-56.00
-55.00
-54.00
-53.00
-52.00
-51.00
-50.00
-49.00
-48.00

Figure 57: Map of Div. 3K showing Crab Management Areas (CMA) and important bathymetric features as well as the Funk Island Deep closed area (blue box).

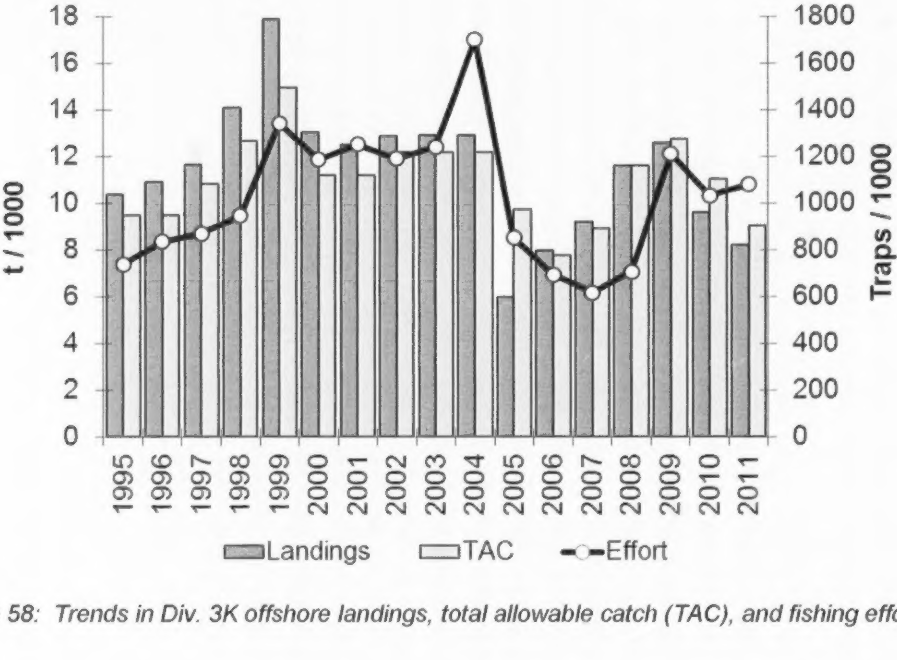


Figure 58: Trends in Div. 3K offshore landings, total allowable catch (TAC), and fishing effort.

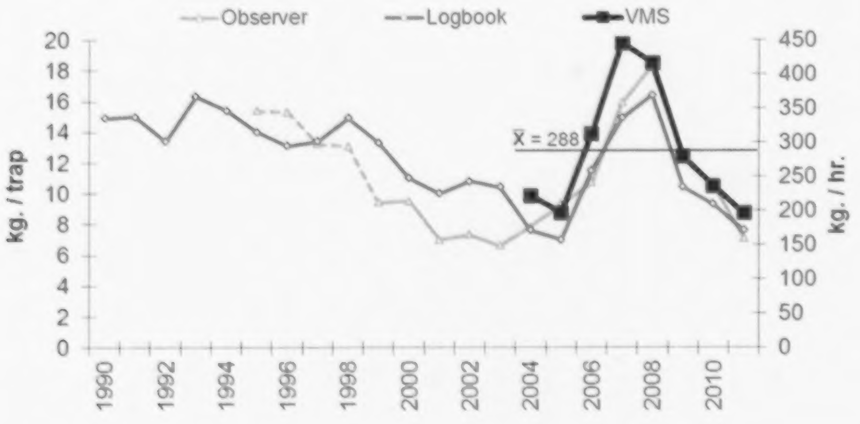


Figure 59: Trends in commercial logbook-based, observer-based, and Vessel Monitoring System (VMS)-based catch per unit effort (CPUE) in the Div. 3K offshore fishery. Solid black line denotes long-term VMS CPUE average.

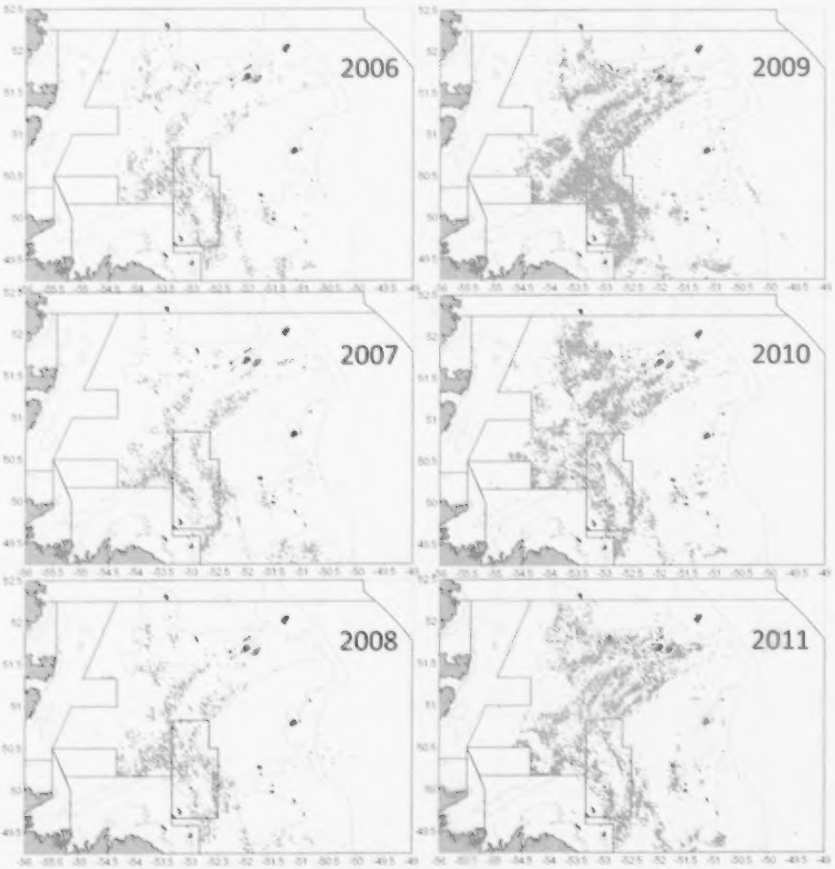


Figure 60: Spatial distribution of Div. 3K offshore fishing effort by year.

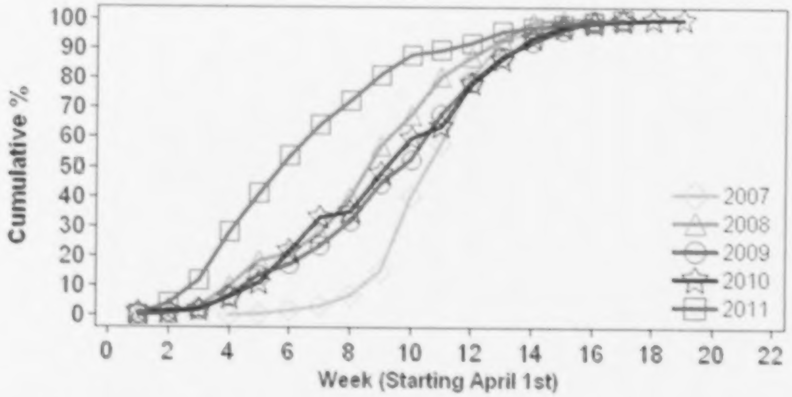


Figure 61: Seasonal trends in fishing effort for Div. 3K offshore during 2007-2011.

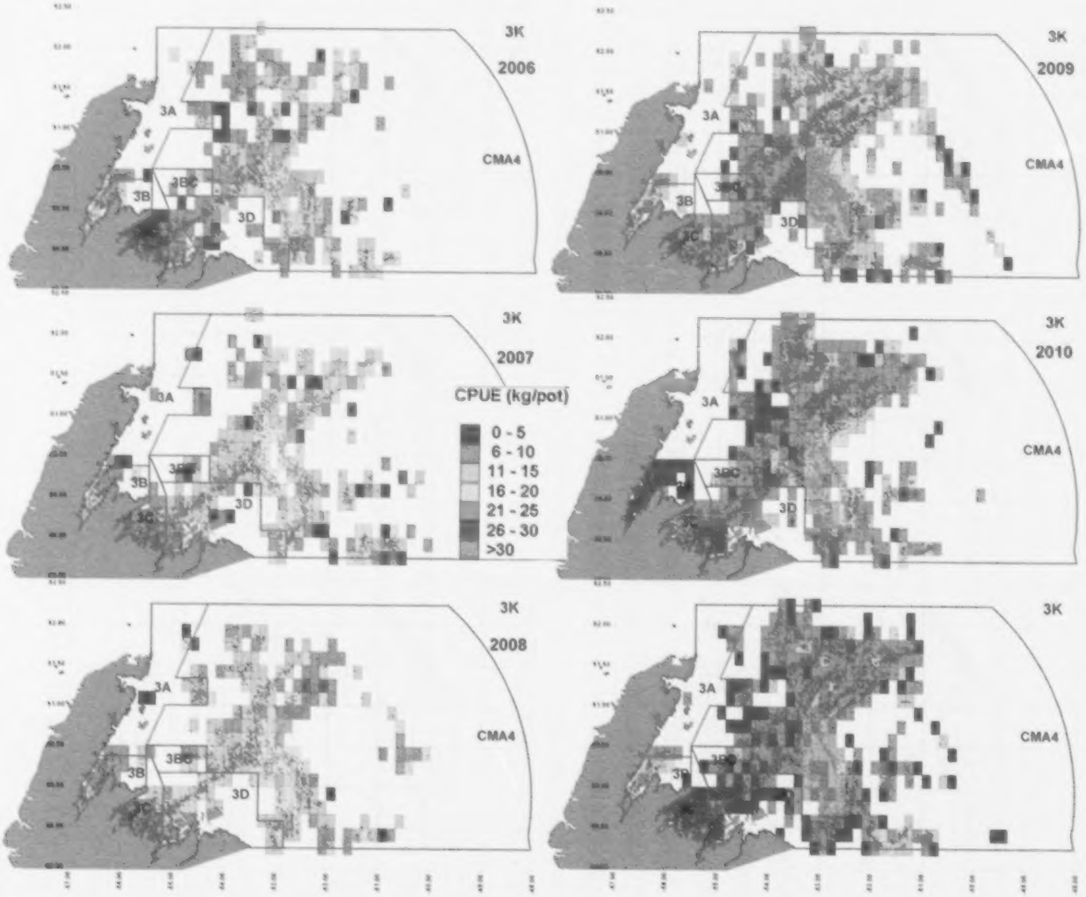

3K
2006
3A
3B
3BC
3D
CMA4
3K
2009
3A
3B
3BC
3C
3D
CMA4
3K
2007
CPUE (kg/pot)
0 - 5
6 - 10
11 - 15
16 - 20
21 - 25
26 - 30
>30
3A
3B
3BC
3C
3D
3K
2010
3A
3BC
3C
3D
CMA4
3K
2008
3A
3B
3BC
3C
3D
CMA4
3K
3A
3B
3BC
CMA4

Figure 62: Spatial distribution of Div. 3K logbook catch per unit effort (CPUE) by year.

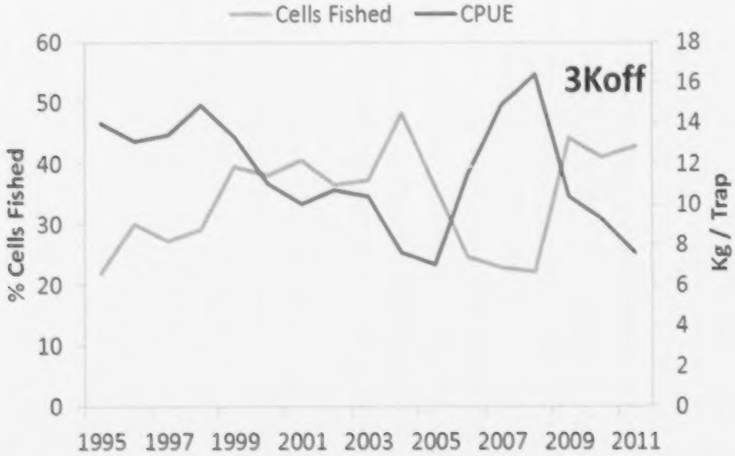


Figure 63: Trends in Div. 3K offshore commercial catch per unit effort (CPUE) vs. the percentage of 5' x 5' cells fished.

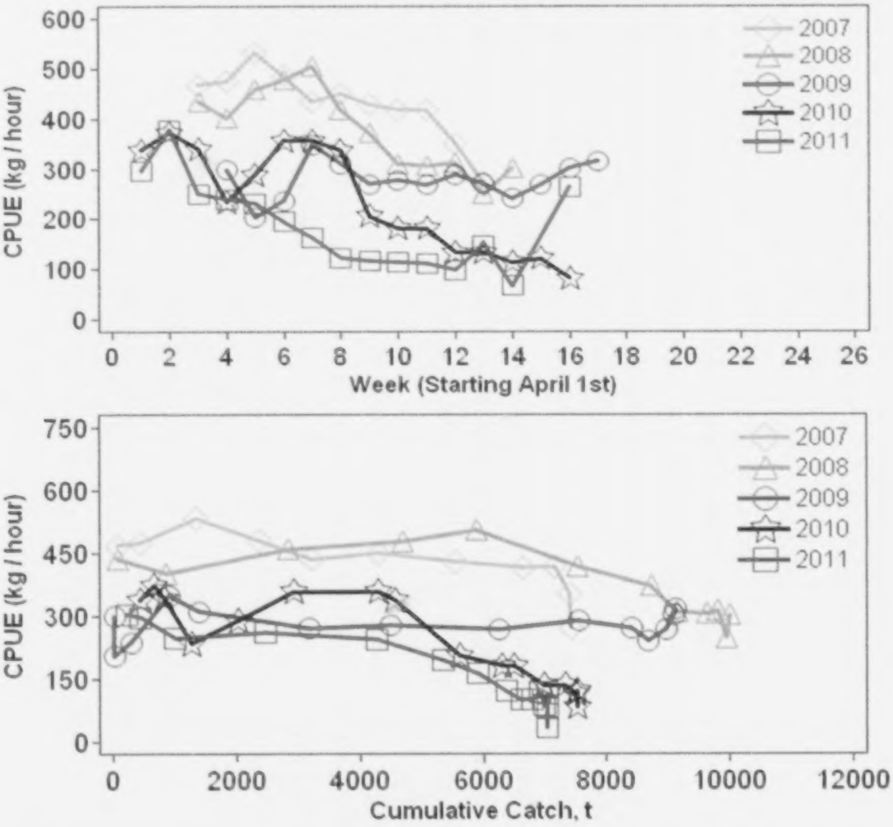


Figure 64: Seasonal trends in Vessel Monitoring System (VMS)-based catch per unit effort (CPUE) for Div. 3K offshore during 2007-2011; by week, (above) and in relation to cumulative catch (below).

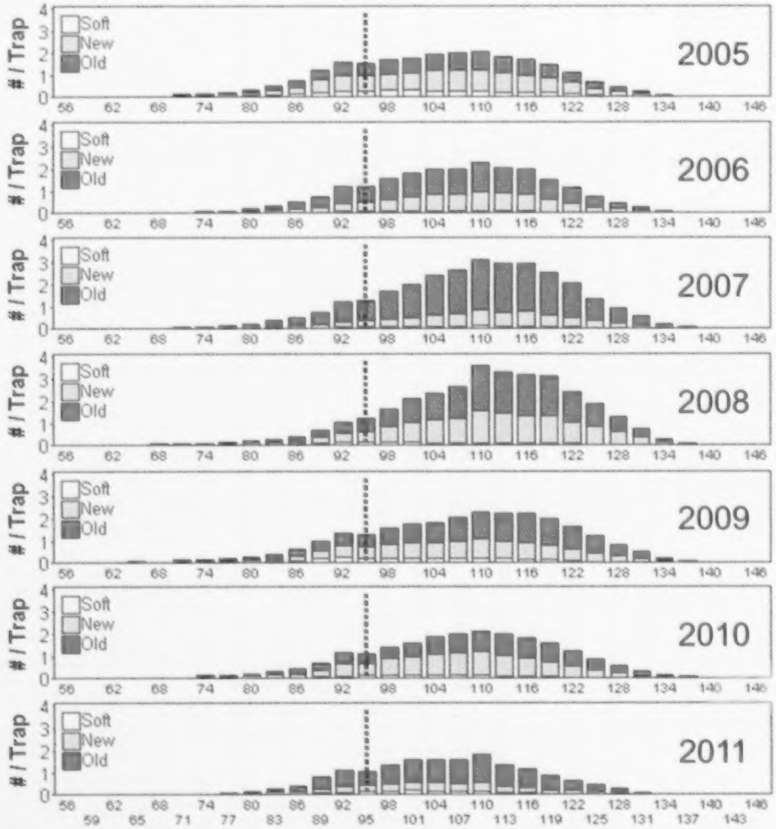


Figure 65: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Div. 3K offshore. The vertical dashed line indicates the minimum legal size.

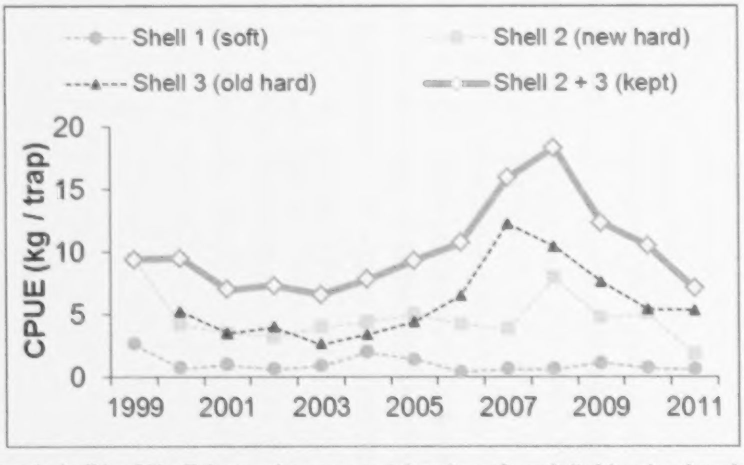


Figure 66: Trends in Div. 3K offshore observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

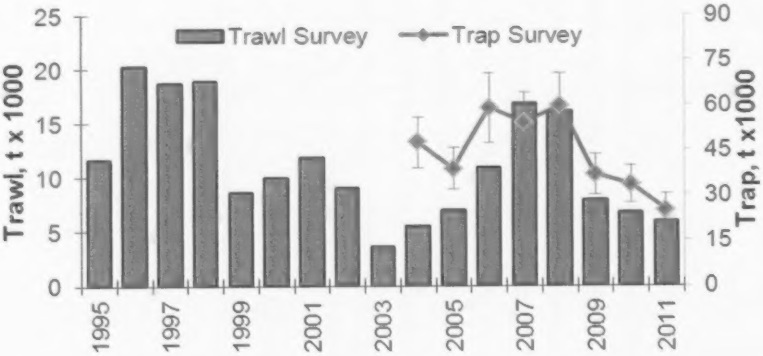


Figure 67: Trends in the Div. 3K offshore fall trawl survey exploitable biomass index and the Collaborative Post-Season (CPS) trap survey exploitable biomass index.

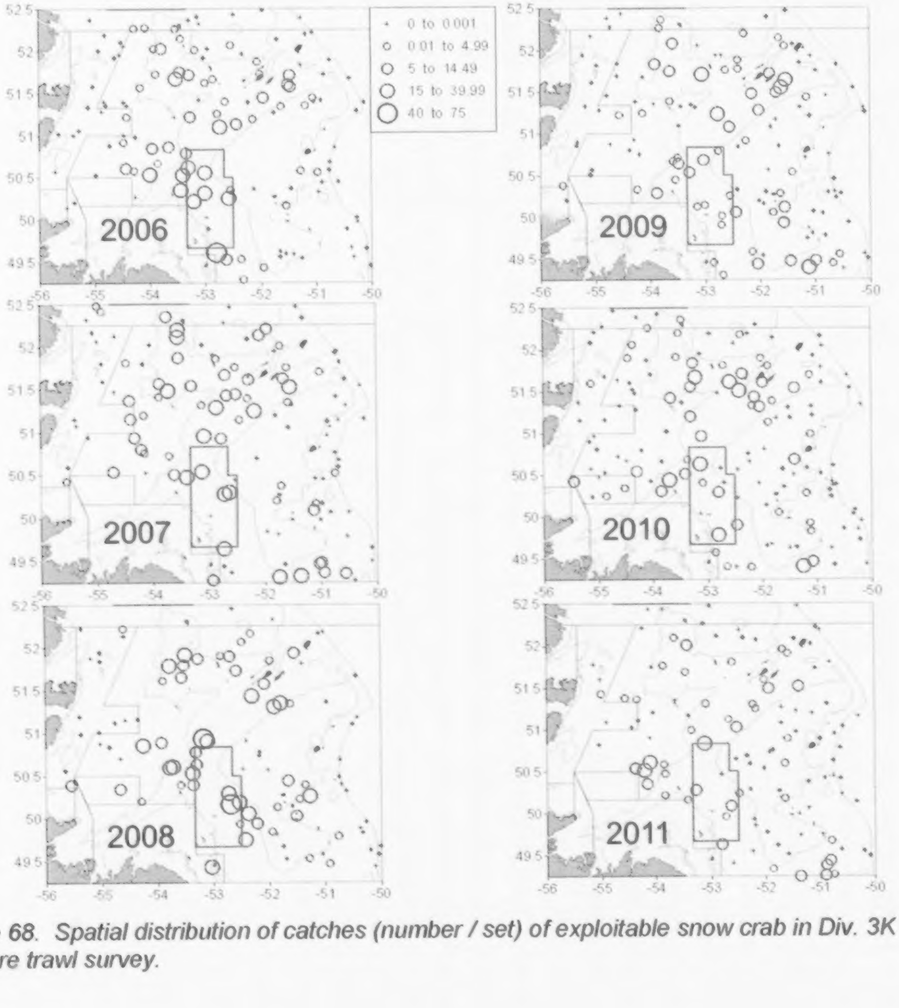

0 to 0.001
0.01 to 4.99
5 to 14.49
15 to 39.99
40 to 75
2006
2007
2008
2009
2010
2011
52.5
52
51.5
51
50.5
50
49.5
-56
-55
-54
-53
-52
-51
-50

Figure 68. Spatial distribution of catches (number / set) of exploitable snow crab in Div. 3K offshore trawl survey.

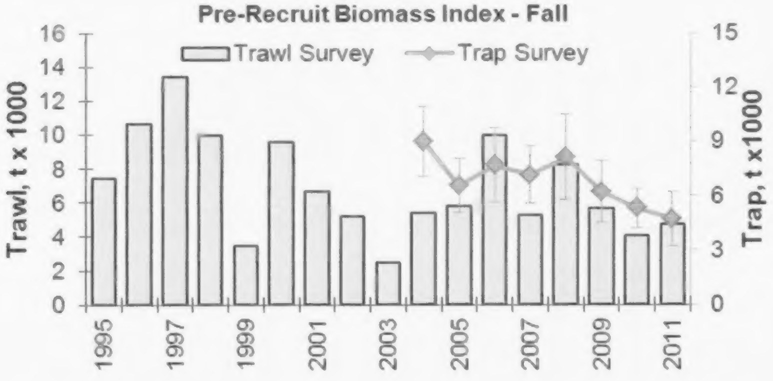


Figure 69: Trends in the Div. 3K fall trawl survey pre-recruit biomass index and the Collaborative Post-Season (CPS) trap survey pre-recruit biomass index.

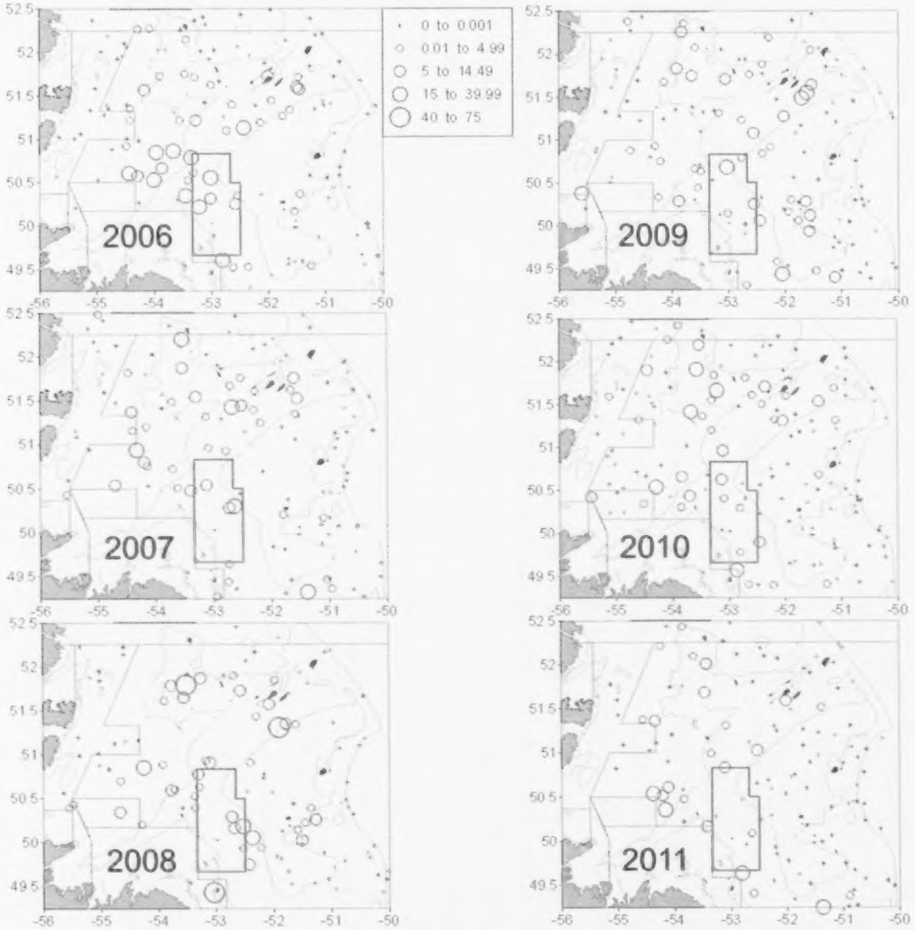

0 to 0.001
0.01 to 4.99
5 to 14.49
15 to 39.99
40 to 75
2006
2007
2008
2009
2010
2011
52.5
52
51.5
51
50.5
50
49.5
-56
-55
-54
-53
-52
-51
-50

Figure 70. Spatial distribution of catches (number / set) of pre-recruit snow crab in the Div. 3K offshore trawl survey.

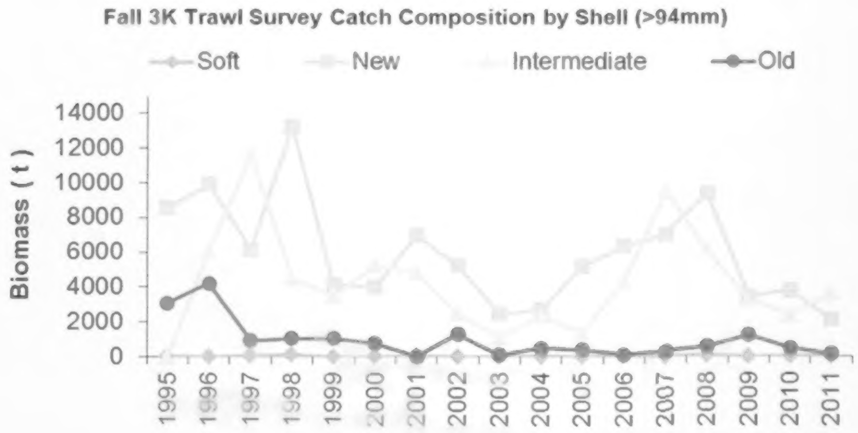


Figure 71: Trends, by shell condition, in biomass of legal-sized males for Div. 3K offshore from fall trawl surveys.

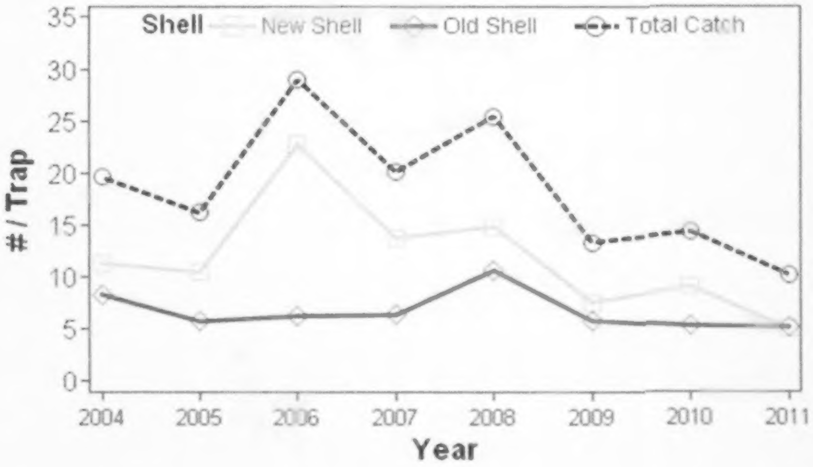


Figure 72: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Div. 3K offshore Collaborative Post-Season (CPS) trap survey.

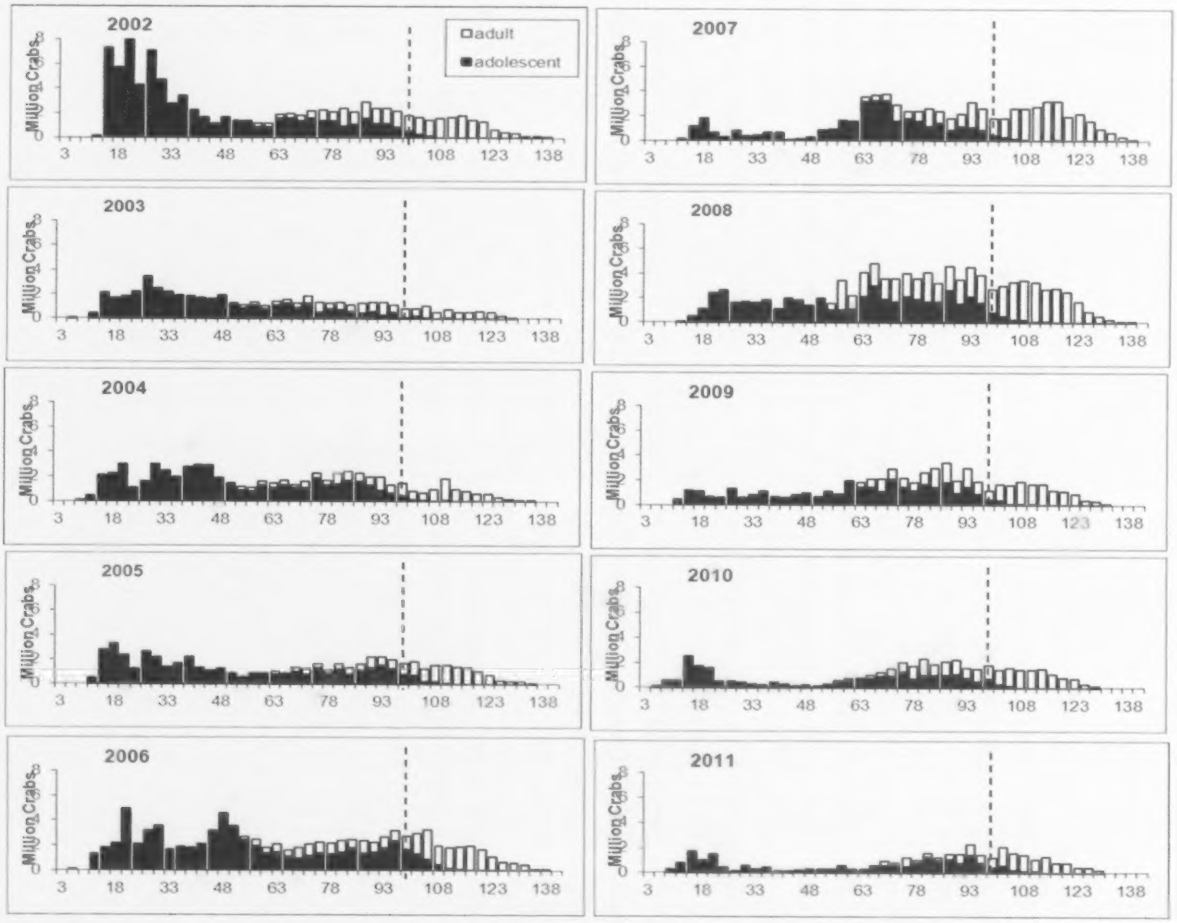


Figure 73: Abundance indices by carapace width for Div. 3K offshore juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys.

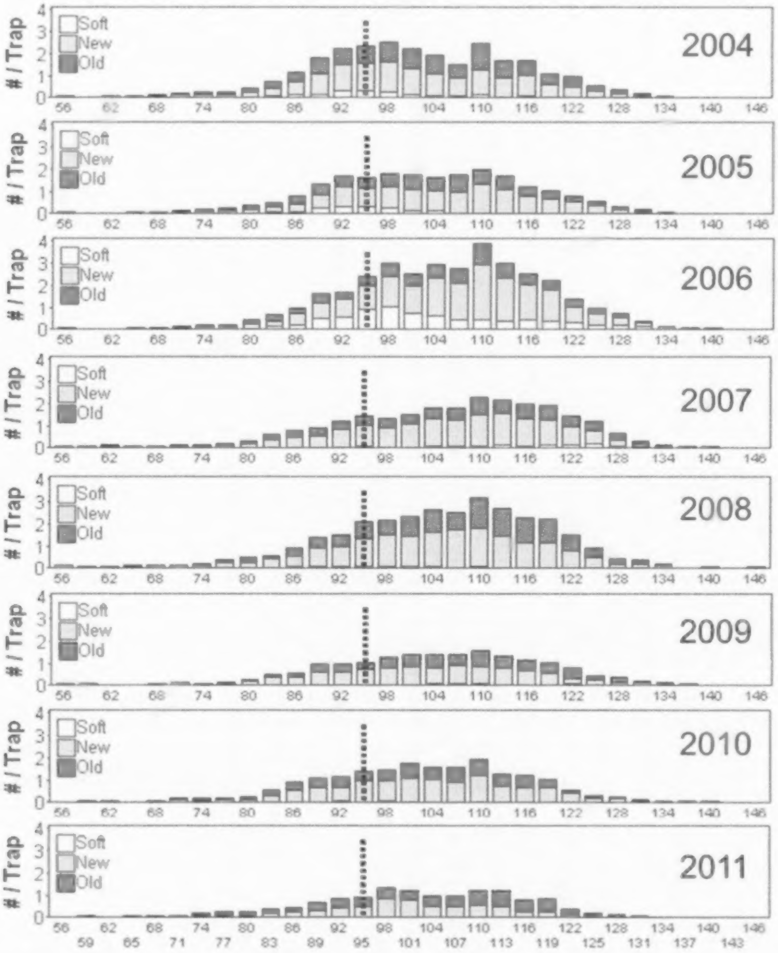


Figure 74: Trends in male carapace width distributions from core stations in the Div. 3K offshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

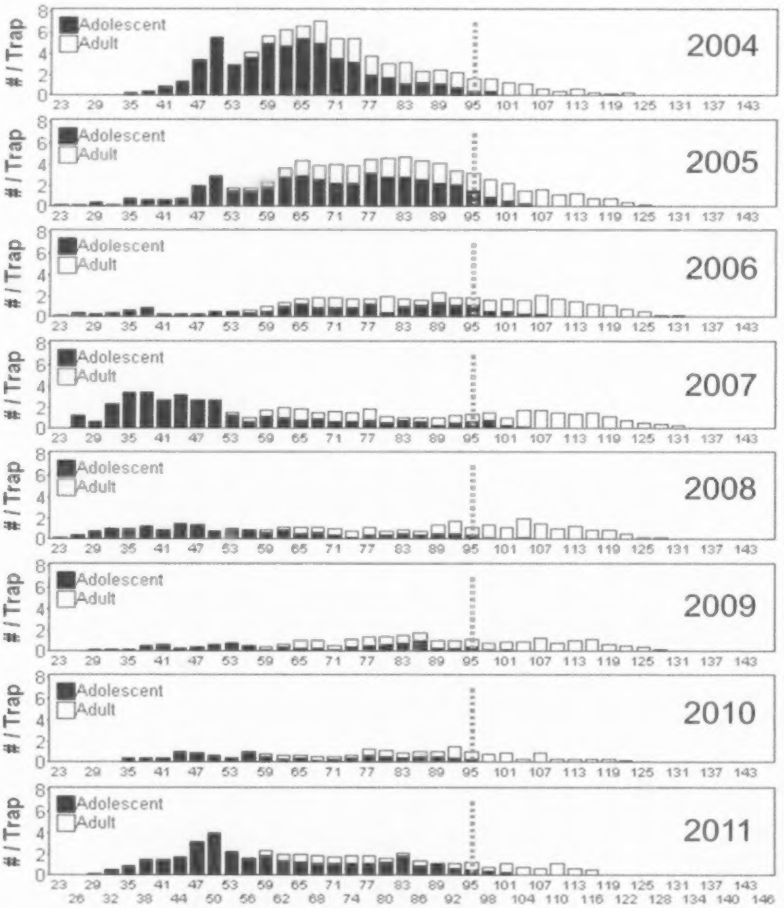


Figure 75: Trends in male carapace width distributions from small-mesh traps in the Div. 3K offshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

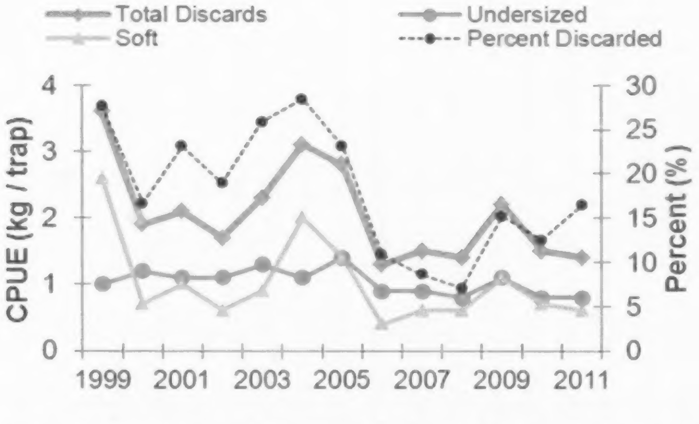


Figure 76: Trends in Div. 3K offshore observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

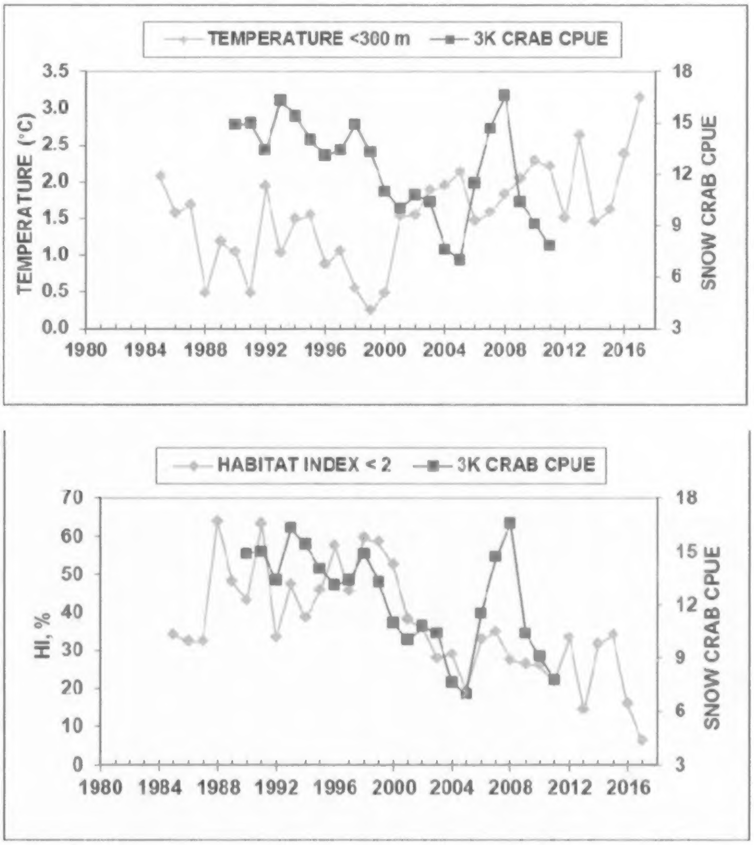


Figure 77: Trends in the Div. 3K offshore catch per unit effort (CPUE) vs. bottom temperature (above) and the spatial extent of <2 degree water (below) at a six year lag.

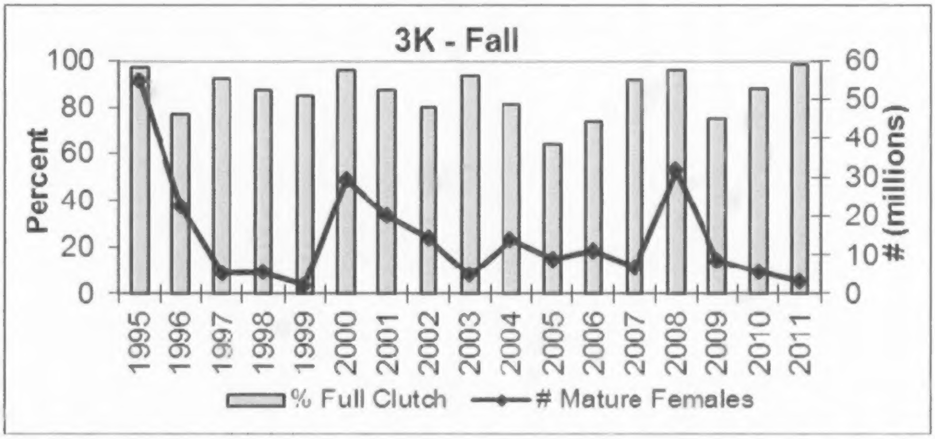


Figure 78: Trends in mature female abundance and percentage bearing full clutches of viable eggs in Div. 3K from fall multi-species surveys.

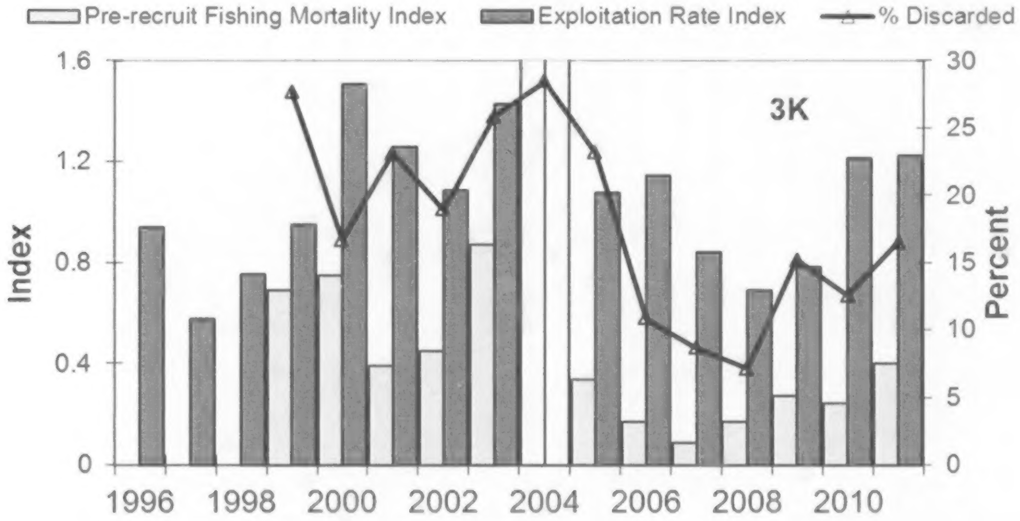


Figure 79: Trends in Div. 3K offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery (anomalously high 2004 values are attributable to low catch rates in 2003 trawl survey).

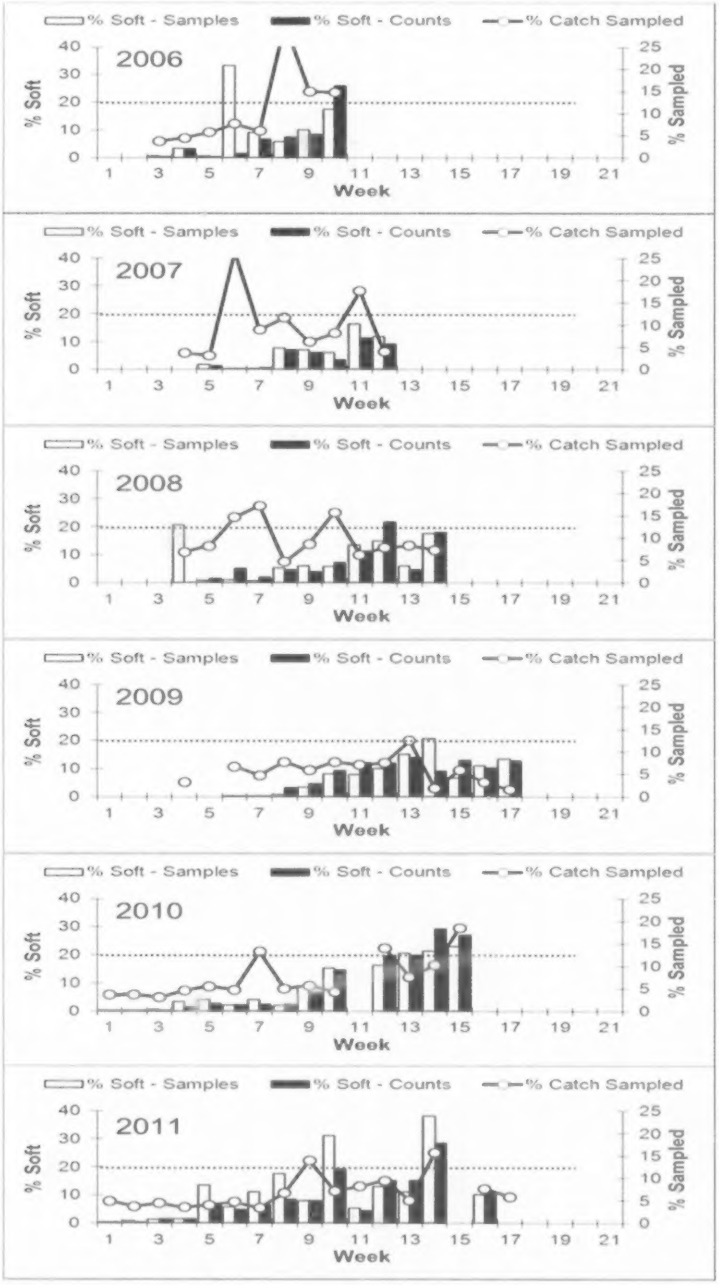


Figure 80: Trends in weekly percentages of soft-shell crab monitored and sampled in Div. 3K offshore from 2006 to 2011.

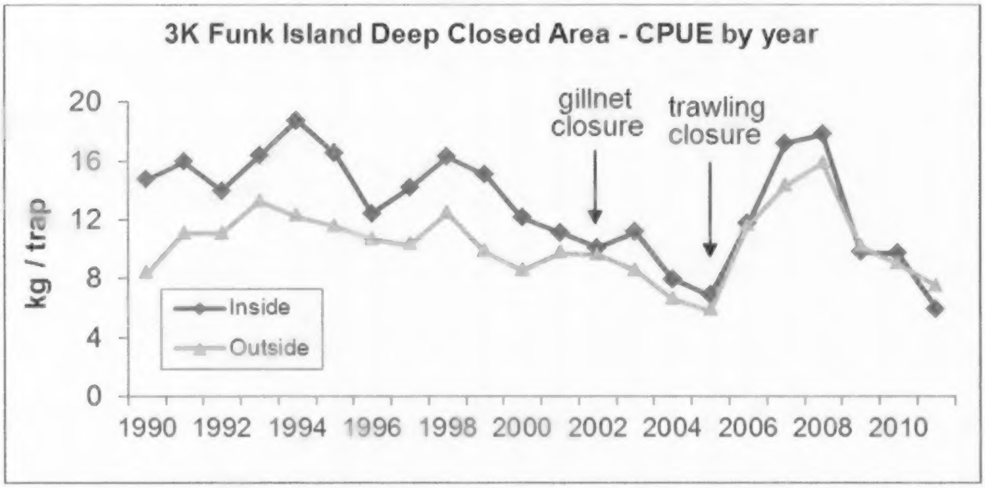


Figure 81: Div. 3K offshore commercial catch per unit effort (CPUE); inside vs. outside the Funk Island Deep closed area.

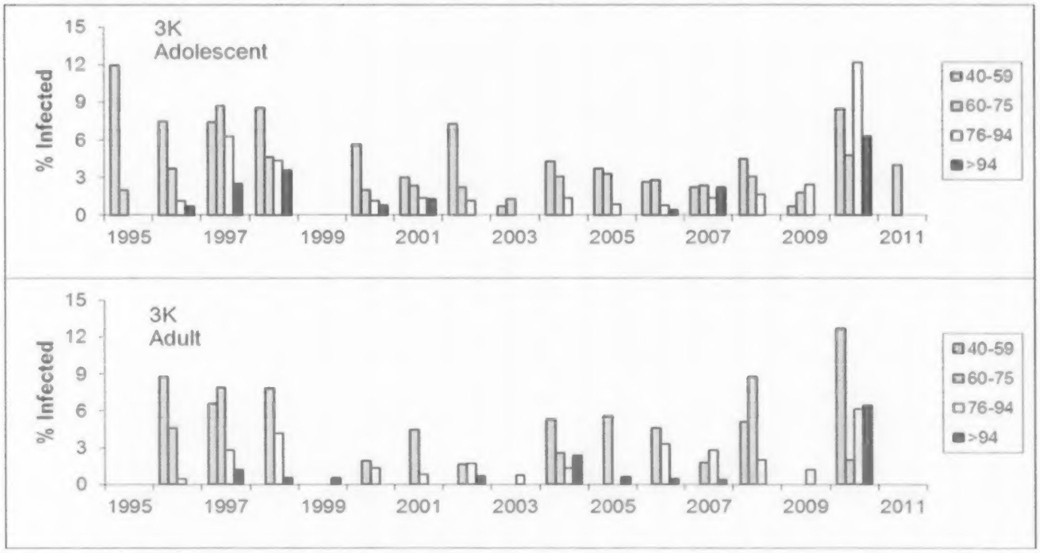


Figure 82: Trends in prevalence of Bitter Crab Disease (BCD) in new-shelled adolescents (above) and adults (below) by male size group from Div. 3K fall trawl surveys.

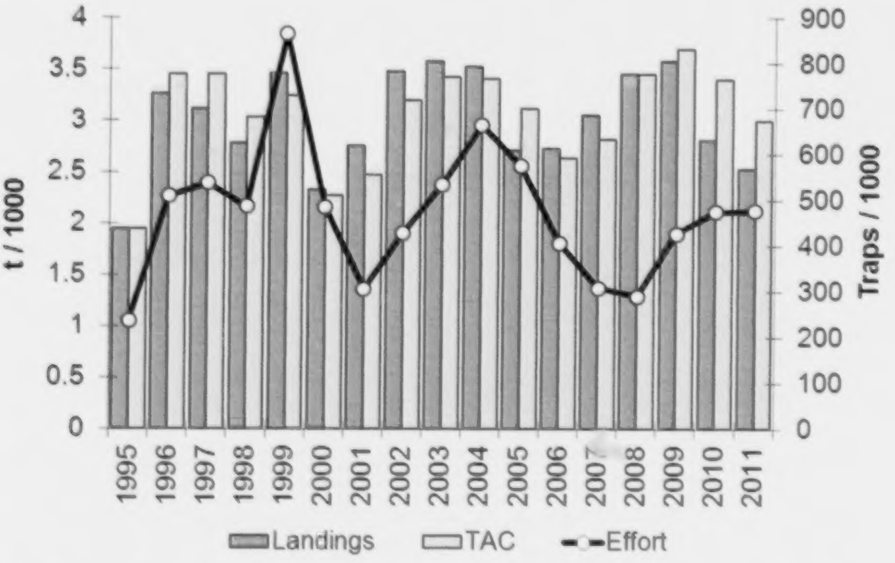


Figure 83: Trends in Div. 3K inshore landings, total allowable catch (TAC), and fishing effort.

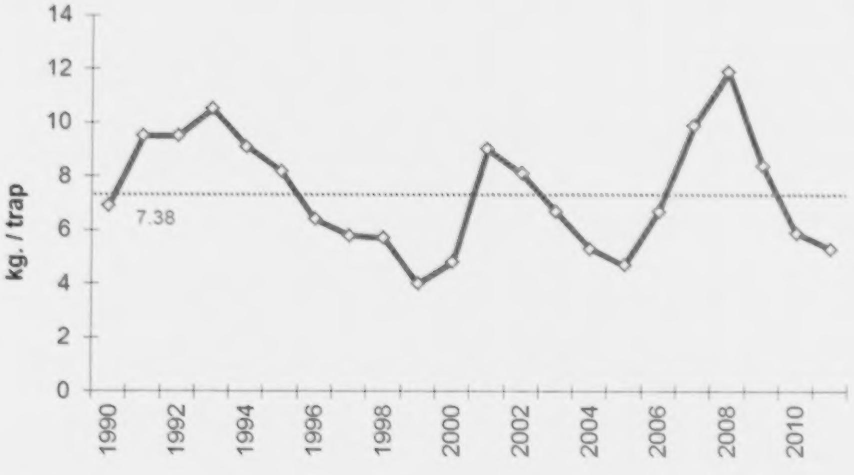


Figure 84: Trends in commercial logbook-based catch per unit effort (CPUE) in the Div. 3K inshore fishery. Dashed line denotes the long-term average.

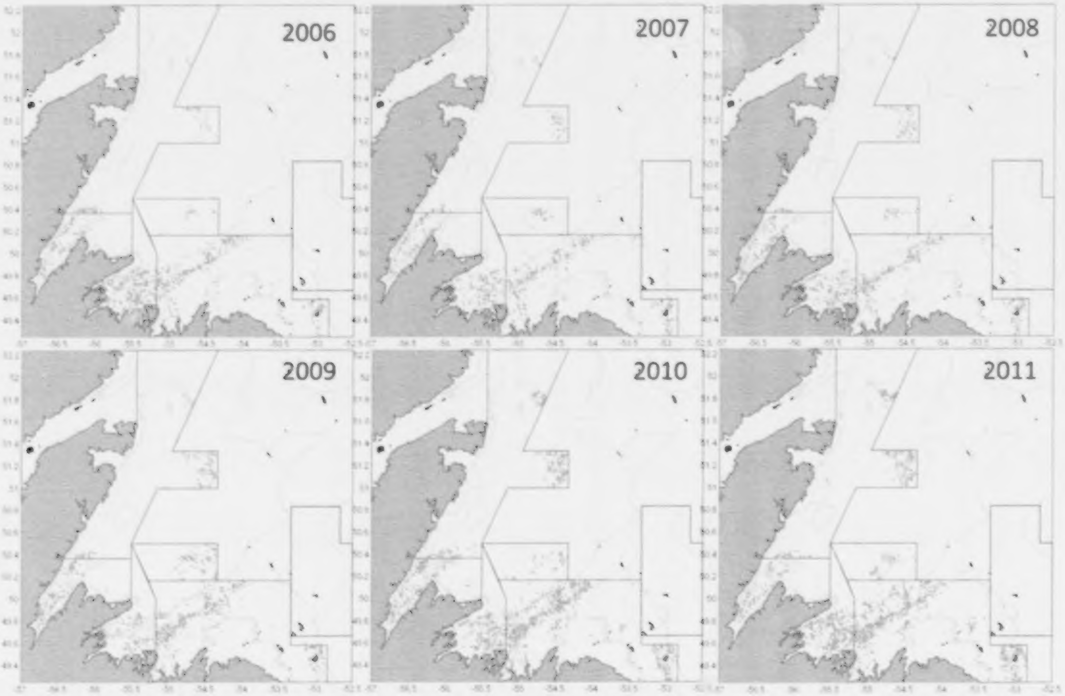

2006
2007
2008
2009
2010
2011

Figure 85: Spatial distribution of Div. 3K inshore fishing effort by year.

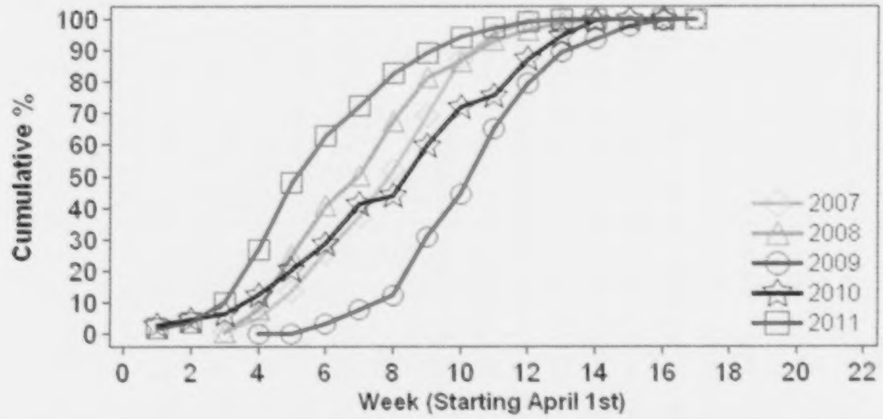


Figure 86: Seasonal trends in weekly fishing effort for Div. 3K inshore during 2007-2011.

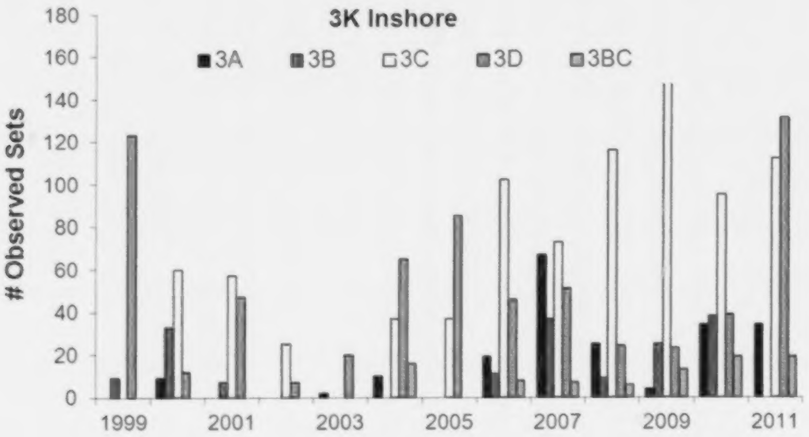


Figure 87: Trends in number of observed sets by Crab Management Areas (CMA) and year in Div. 3K inshore.

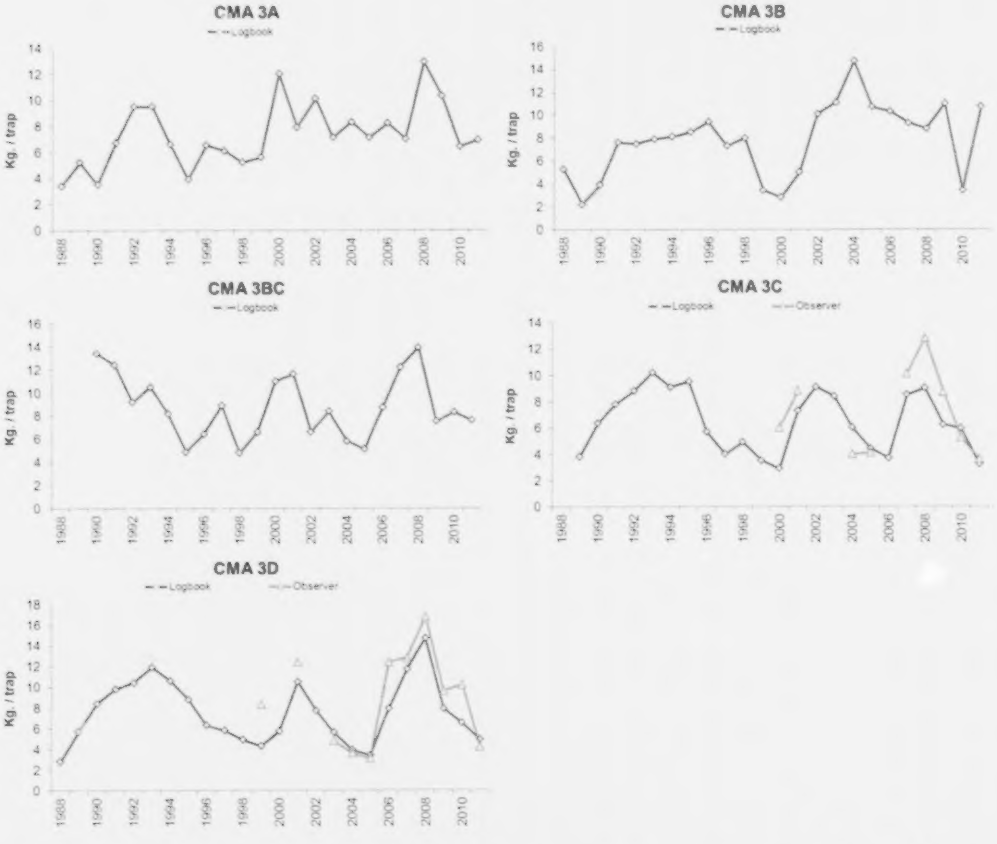


Figure 88: Trends in Div. 3K inshore logbook catch per unit effort (CPUE) and observer CPUE by Crab Management Area (CMA).

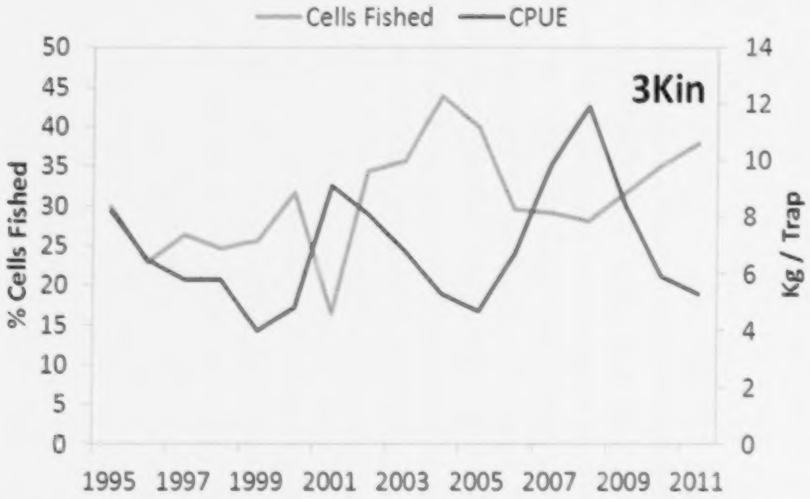


Figure 89: Trends in Div. 3K inshore commercial catch per unit effort (CPUE) vs. the percentage of 5' x 5' cells fished.

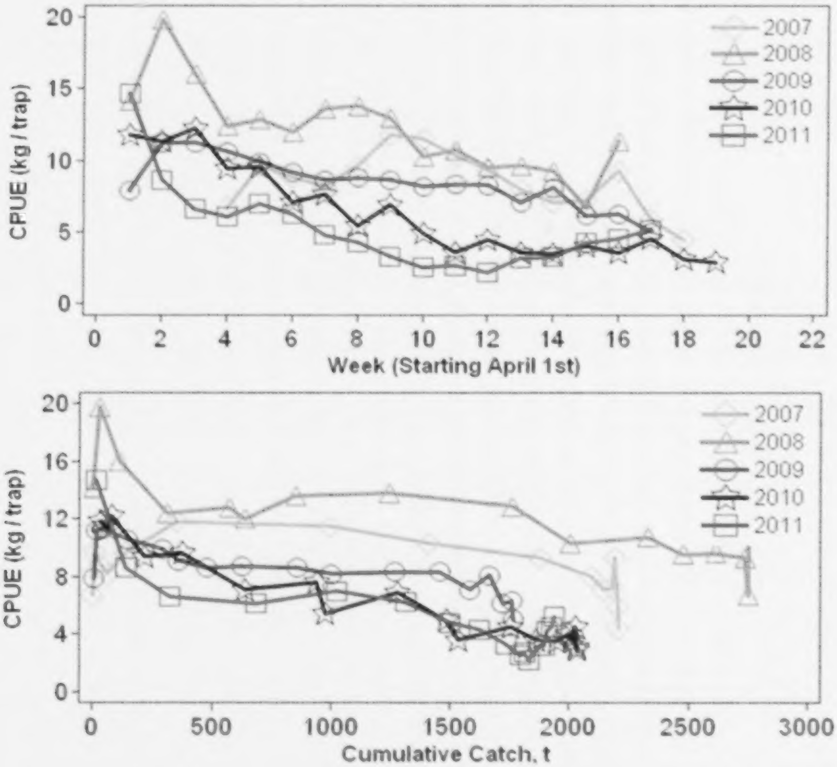


Figure 90: Seasonal trends in logbook-based catch per unit effort (CPUE) for Div. 3K inshore during 2007-2011 by week (above), and in relation to cumulative catch (below).

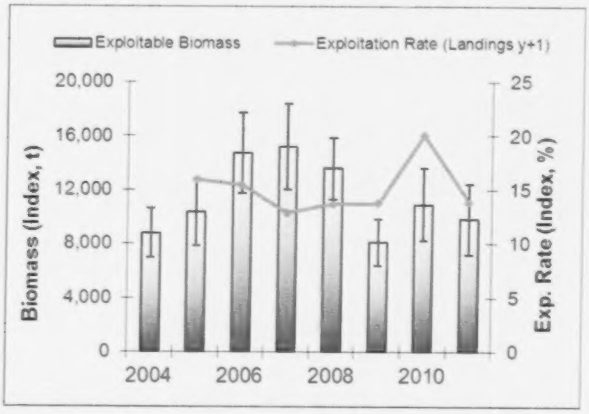


Figure 91: Exploitable biomass and exploitation rate indices from the Collaborative Post-Season (CPS) trap survey in Div. 3K inshore.

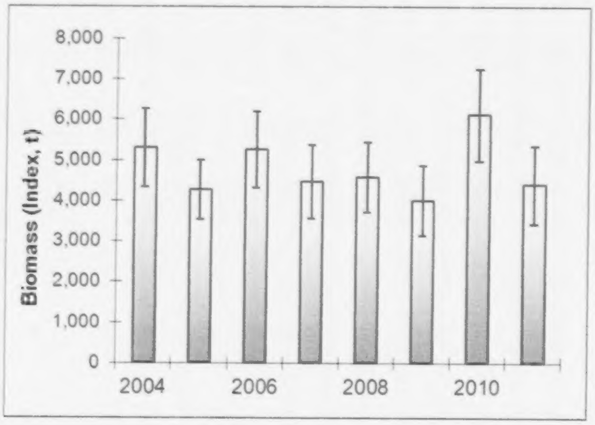


Figure 92: Pre-recruit biomass index based on the Collaborative Post-Season (CPS) trap survey in Div. 3K inshore.

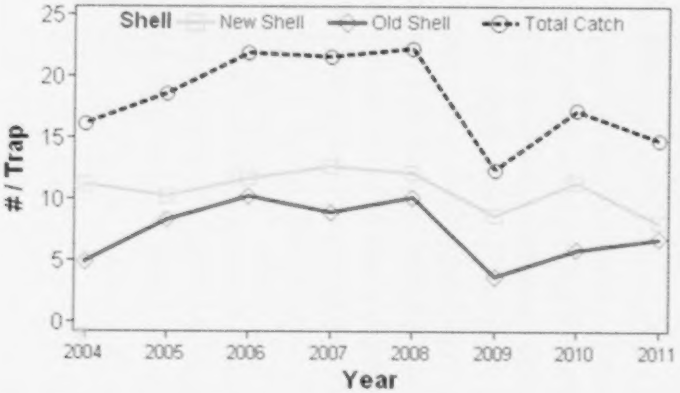


Figure 93: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Div. 3K inshore.

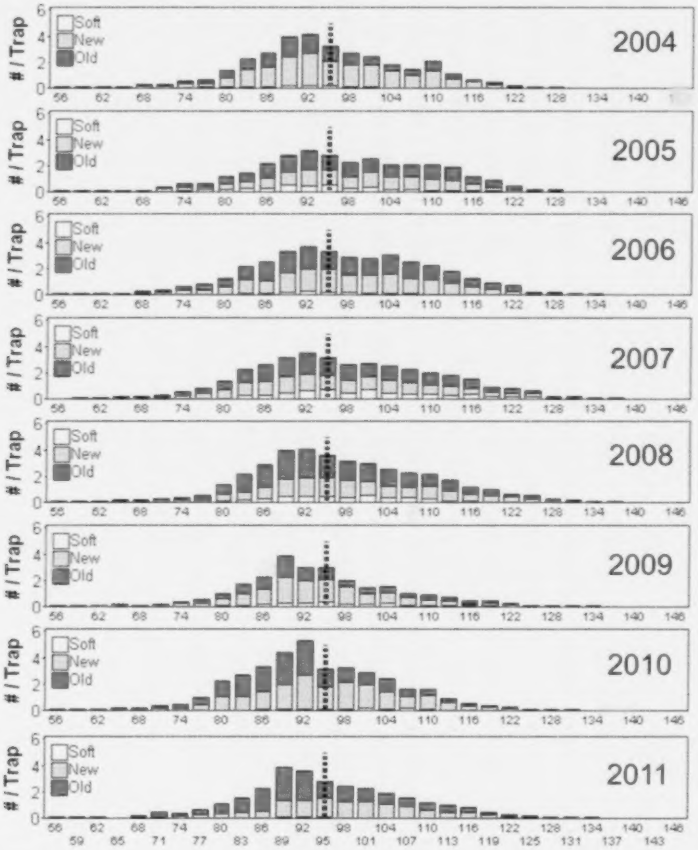


Figure 94: Trends in male carapace width distributions from core stations in the Div. 3K inshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

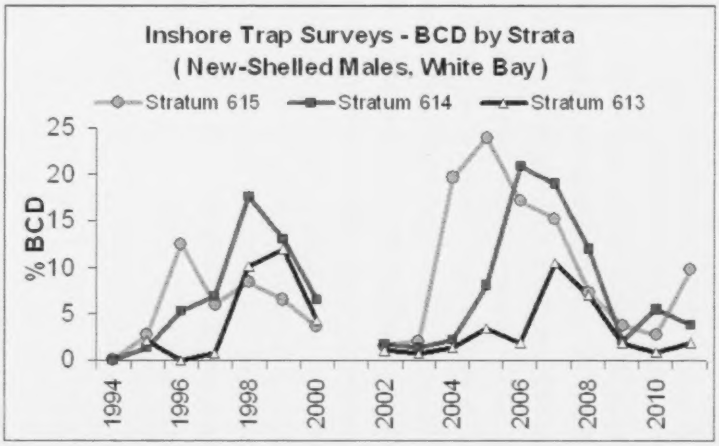


Figure 95: Prevalence of Bitter Crab Disease (BCD) in new-shelled males from Div. 3K DFO inshore trap surveys by stratum in White Bay.

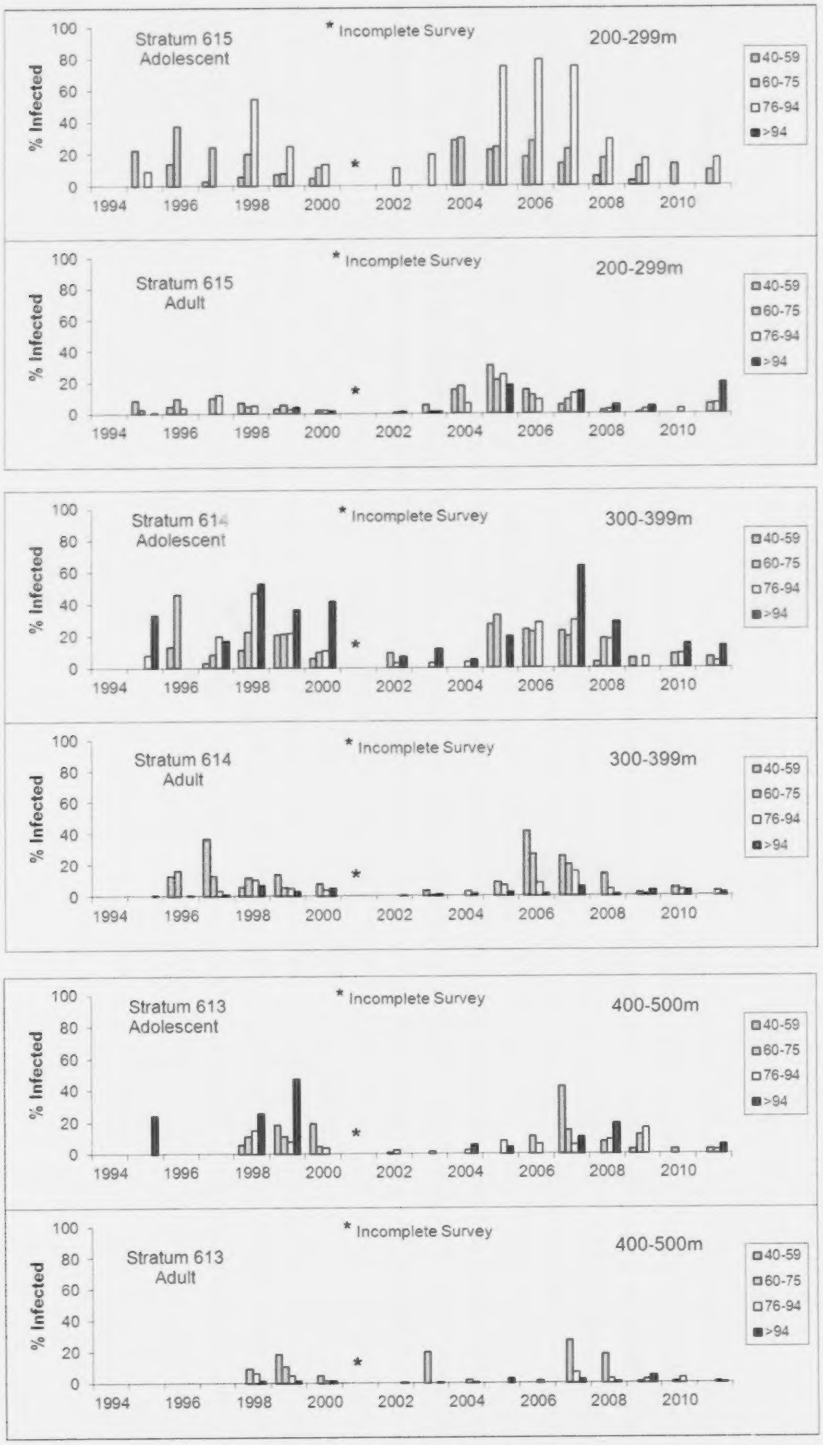


Figure 96: Trends of prevalence of Bitter Crab Disease (BCD) in new-shelled males by stratum, year and size group from DFO trap surveys in White Bay; adolescents (above) and adults (below).

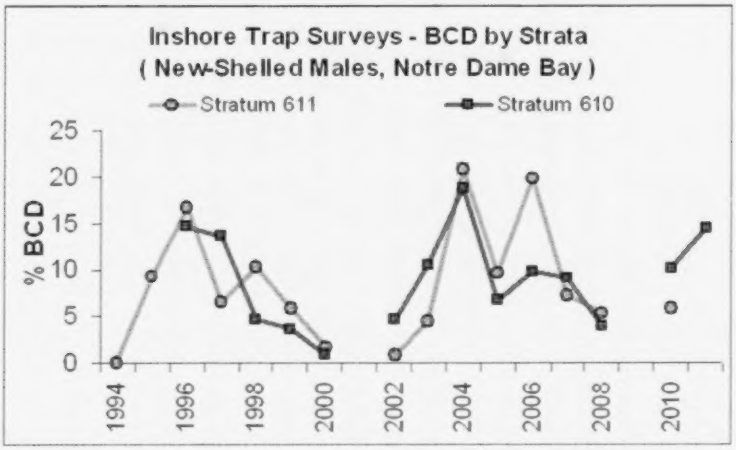


Figure 97: Prevalence of Bitter Crab Disease (BCD) in new-shelled males from Div. 3K DFO inshore trap surveys by stratum in Notre Dame Bay.

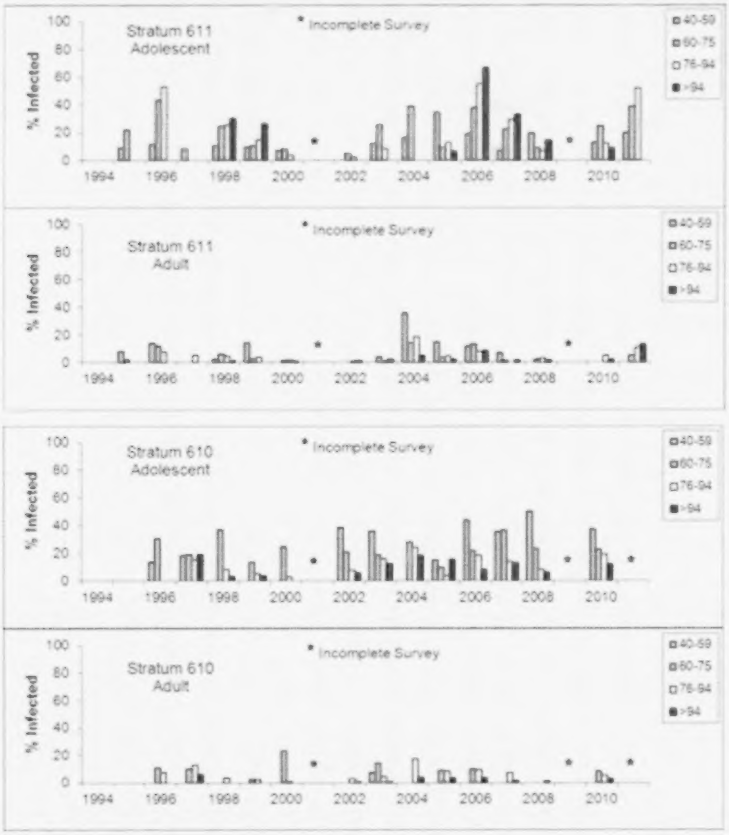


Figure 98: Trends of prevalence of Bitter Crab Disease (BCD) in new-shelled males by stratum, year and size group from DFO trap surveys in Notre Dame Bay; adolescents (above) and adults (below).

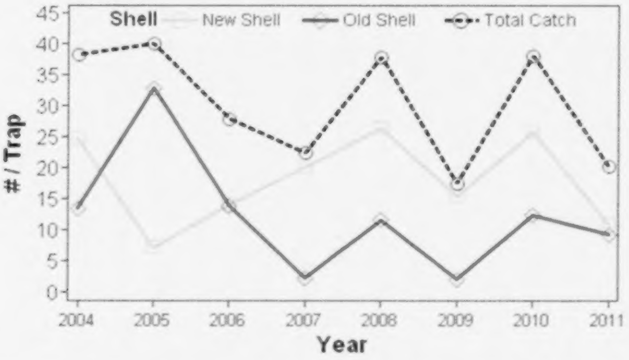


Figure 99: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 3B.

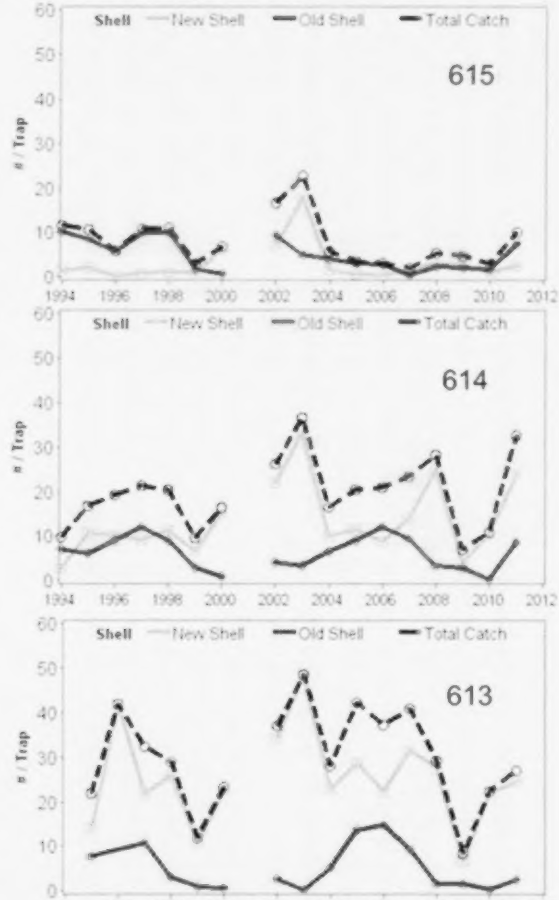


Figure 100: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from strata occupied in the DFO trap survey in White Bay. No survey was conducted in 2001.

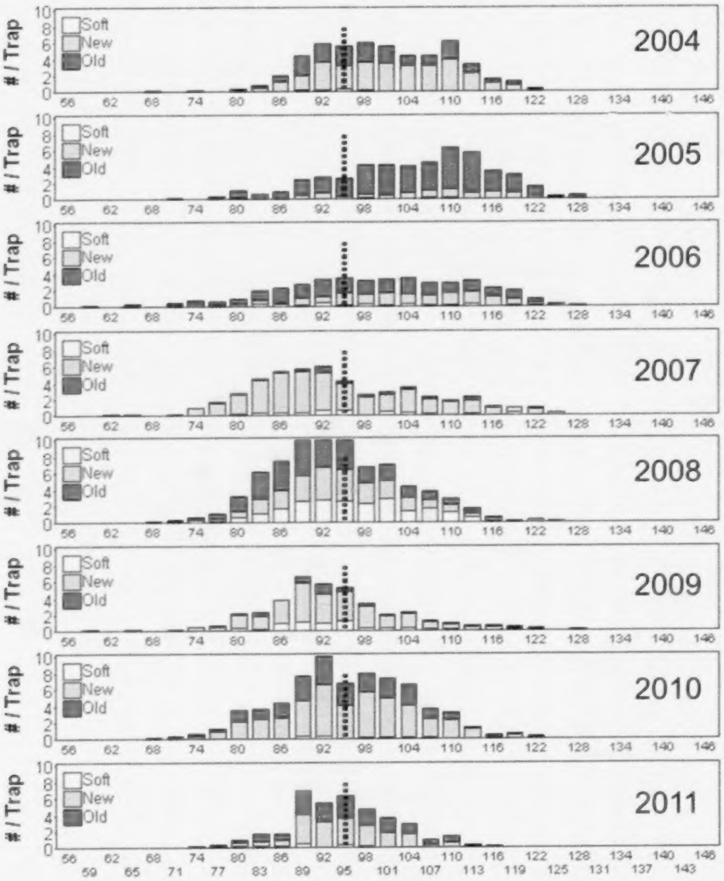


Figure 101: Trends in male carapace width distributions from core stations in Crab Management Area (CMA) 3B from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

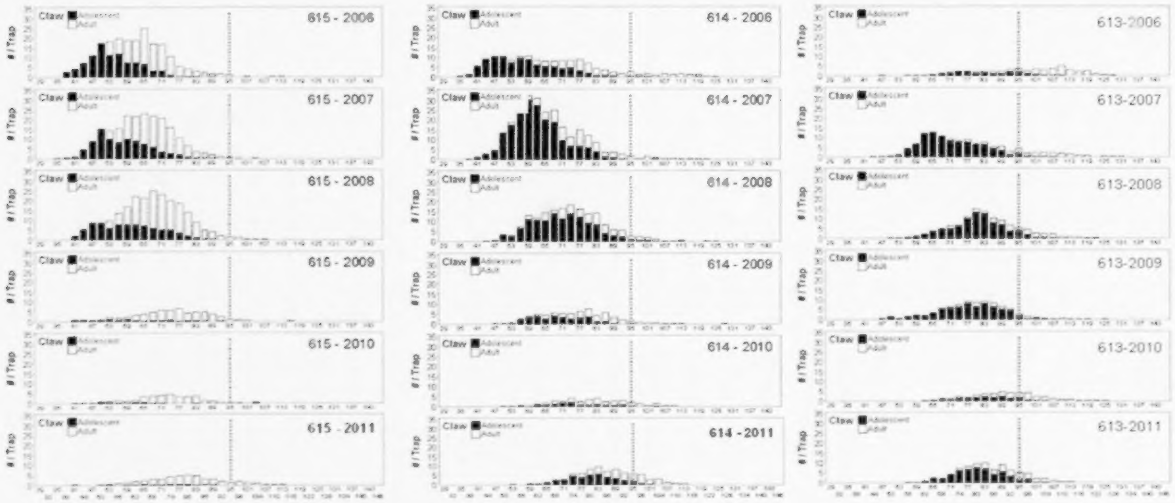


Figure 102: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in the DFO trap survey in White Bay from 2006 to 2010. The vertical dashed line indicates the minimum legal size.

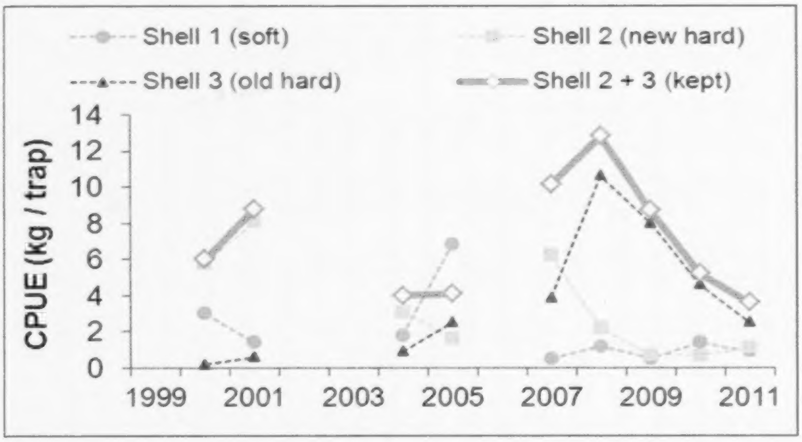


Figure 103: Trends in Crab Management Area (CMA) 3C observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

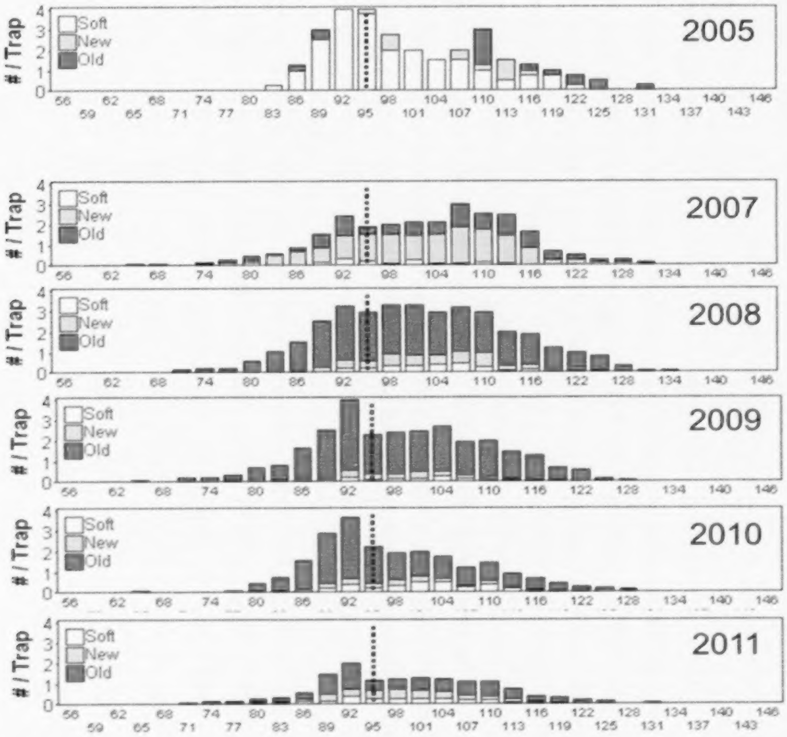


Figure 104: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Crab Management Area (CMA) 3C. The vertical dashed line indicates the minimum legal size.

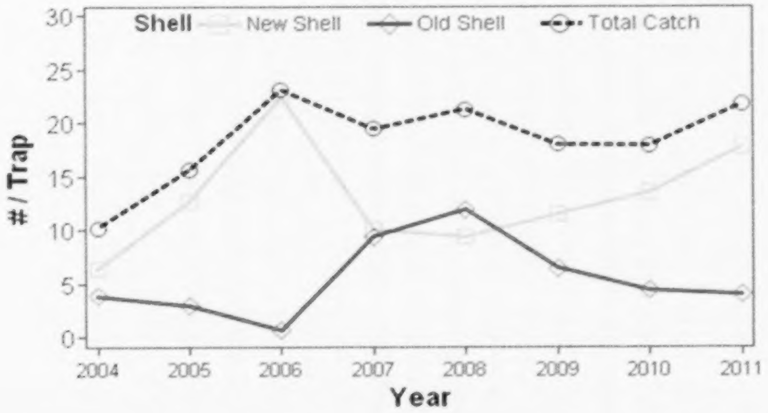


Figure 105: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 3C.

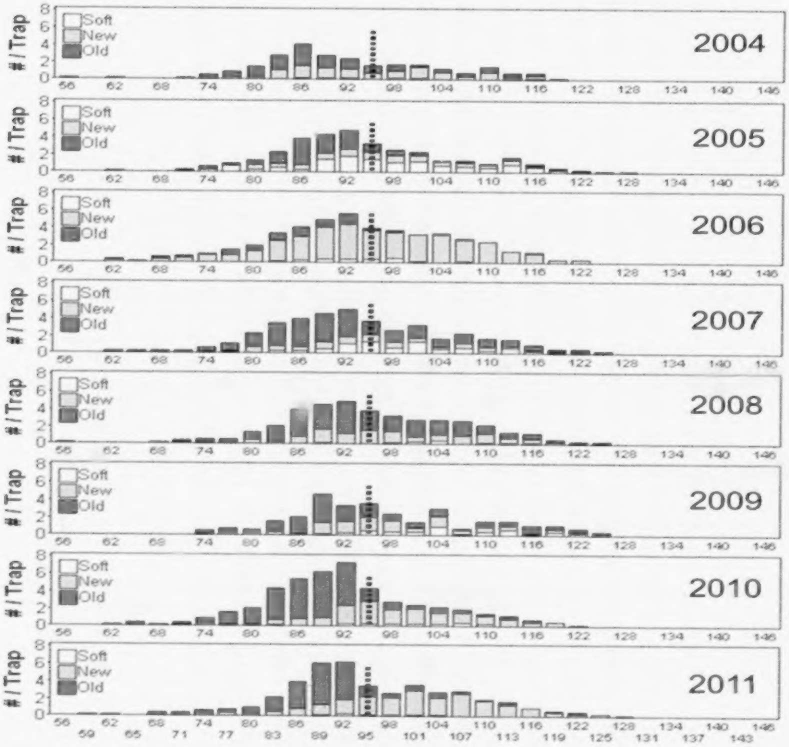


Figure 106: Trends in male carapace width distributions from core stations in Crab Management Area (CMA) 3C from the Collaborative Post-Season (CPS) survey. The vertical dashed line indicates the minimum legal size.

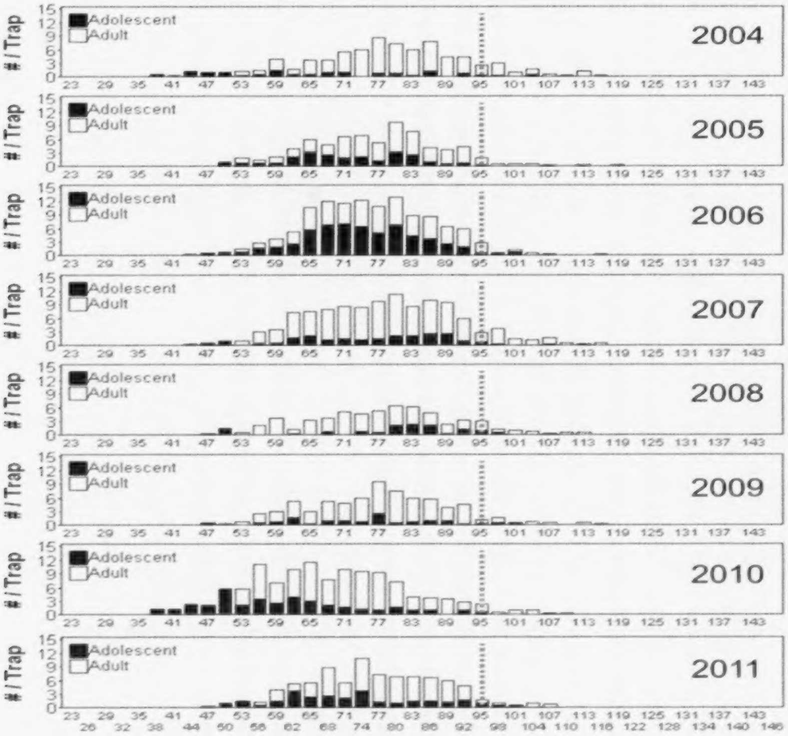


Figure 107: Trends in male carapace width distributions from small-mesh traps in Crab Management Area (CMA) 3C from the Collaborative Post-Season (CPS) survey. The vertical dashed line indicates the minimum legal size.

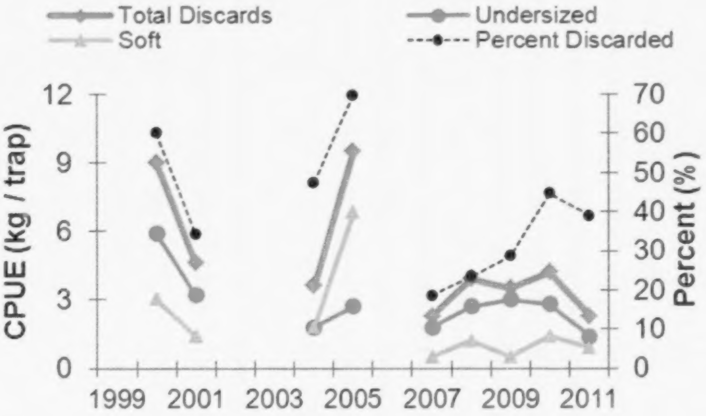


Figure 108: Trends in Crab Management Area (CMA) 3C observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

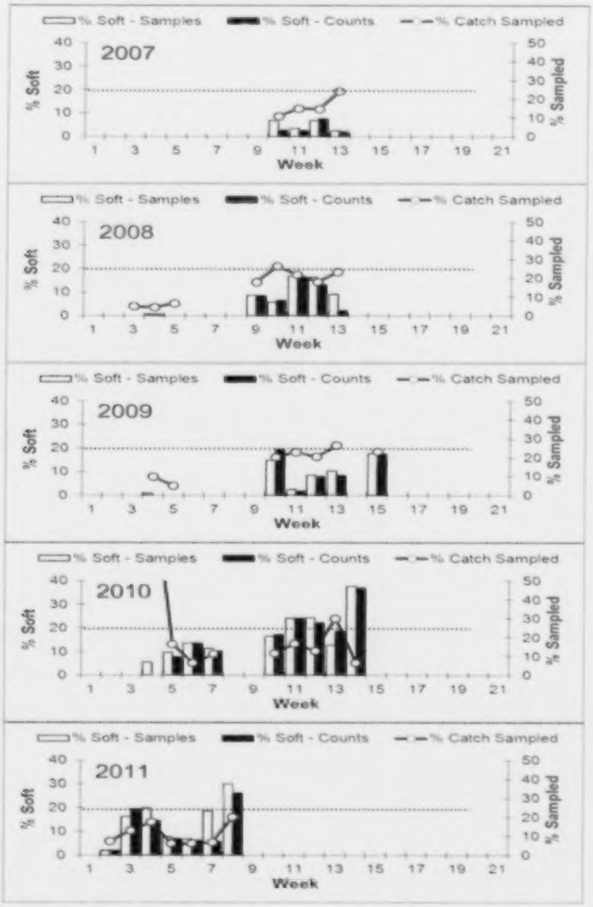


Figure 109: Trends in weekly percentages of soft-shell crab monitored and sampled in Crab Management Area (CMA) 3C from 2007 to 2011.

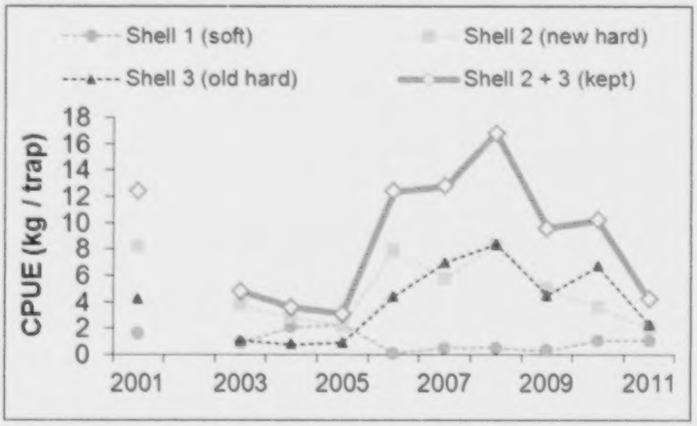


Figure 110: Trends in Crab Management Area (CMA) 3D observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

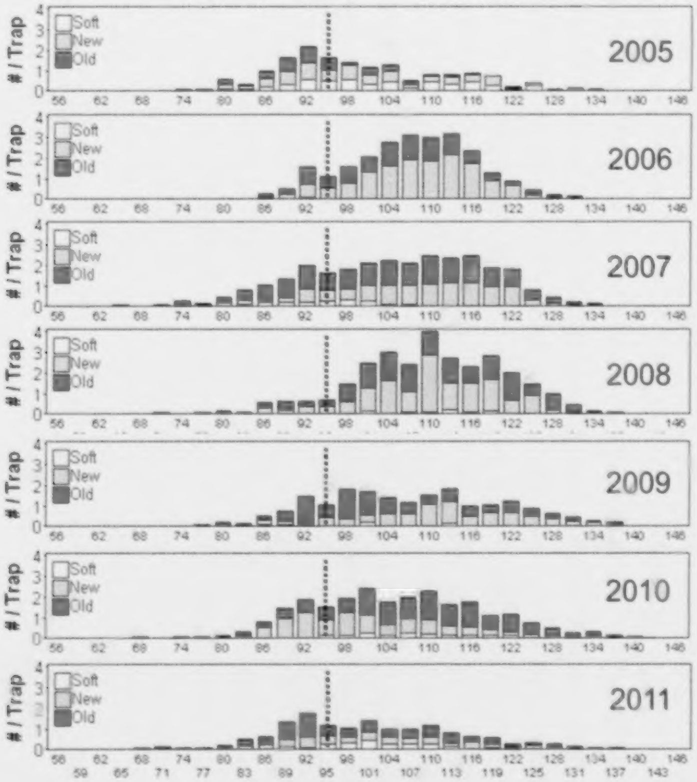


Figure 111: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Crab Management Area (CMA) 3D. The vertical dashed line indicates the minimum legal size.

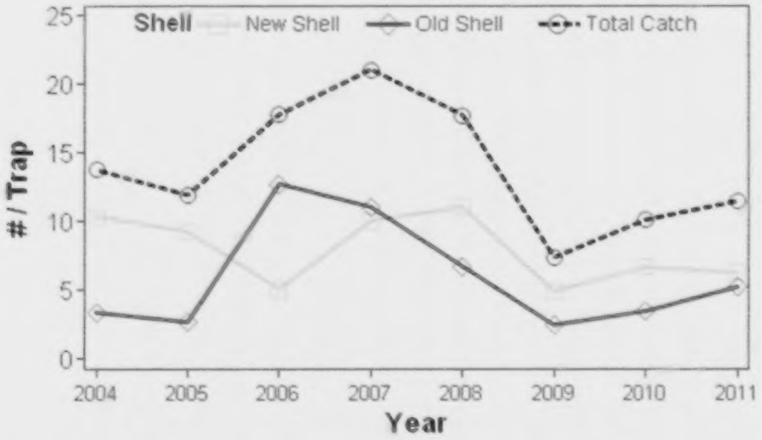


Figure 112: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 3D.

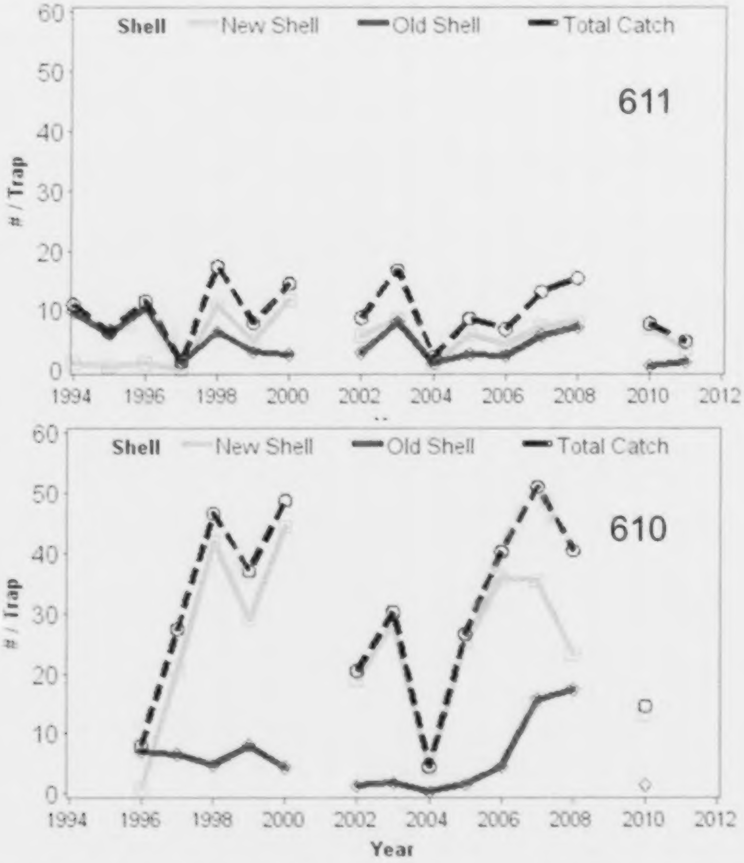


Figure 113: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from strata occupied in the DFO trap survey in Notre Dame Bay. No surveys were conducted in 2001 or 2009.

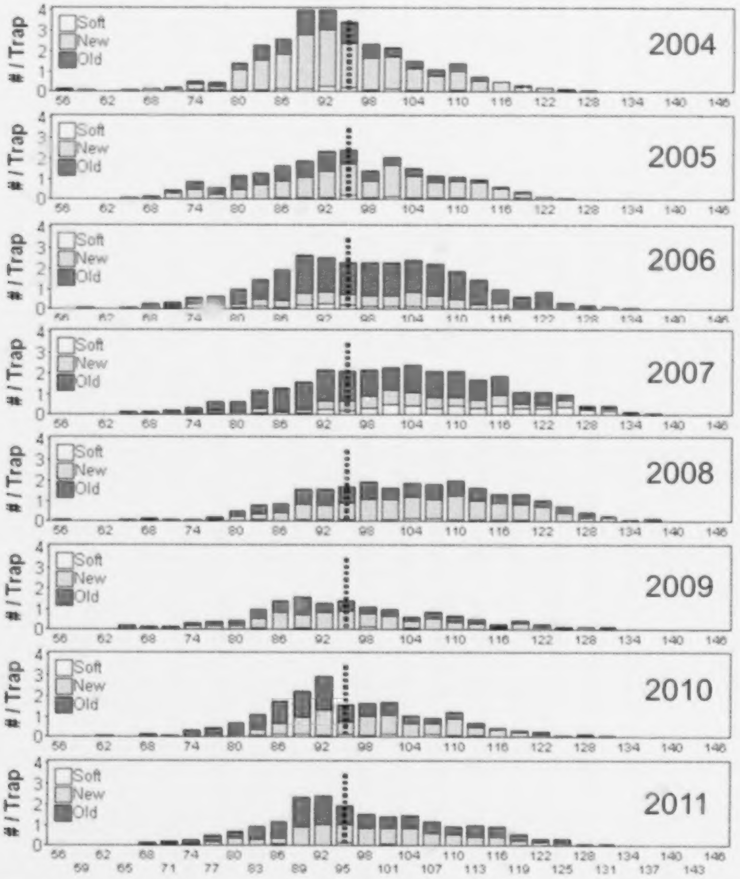


Figure 114: Trends in male carapace width distributions from core stations in Crab Management Area (CMA) 3D from the Collaborative Post-Season (CPS) survey. The vertical dashed line indicates the minimum legal size.

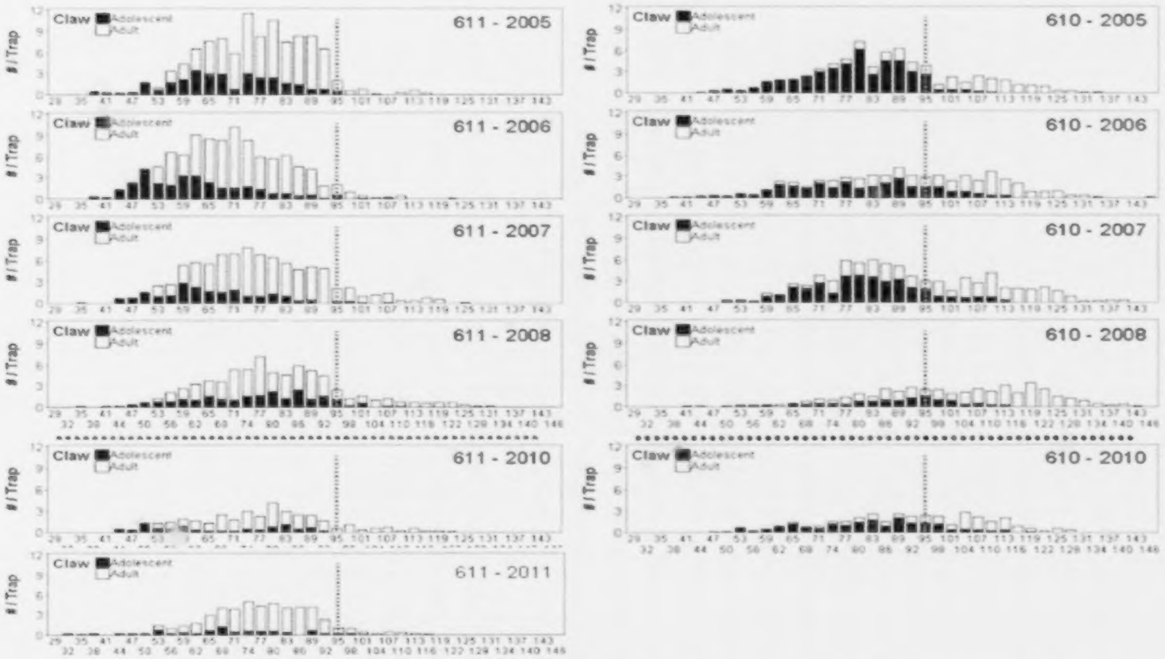


Figure 115: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in DFO trap survey in Notre Dame Bay from 2005 to 2011. The vertical dashed line indicates the minimum legal size.

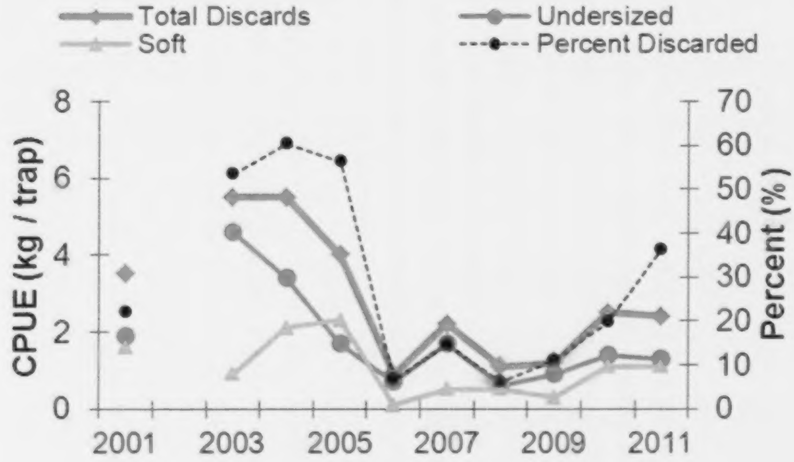


Figure 116: Trends in Crab Management Area (CMA) 3D observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

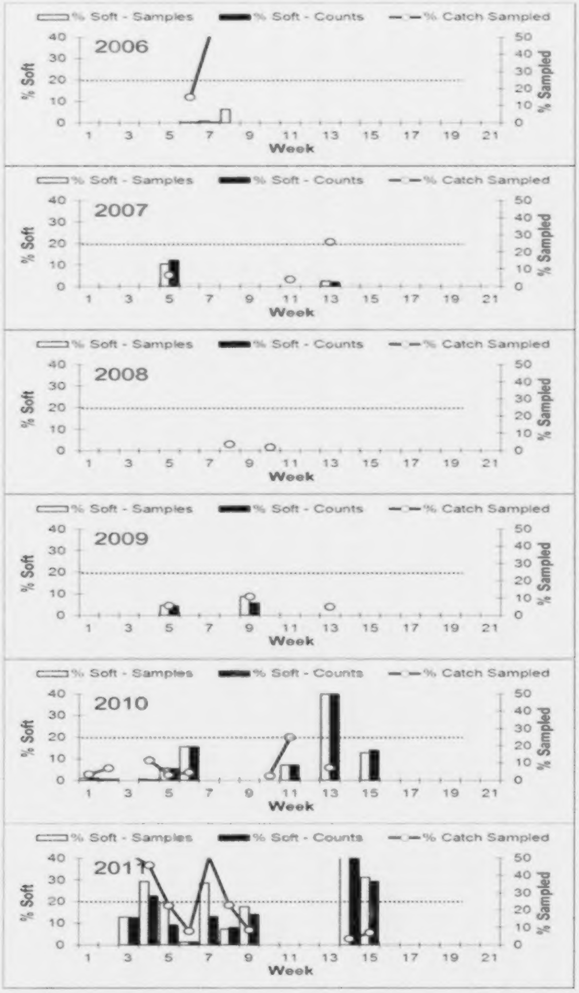


Figure 117: Trends in weekly percentages of soft-shell crab monitored and sampled in Crab Management Area (CMA) 3D from 2006 to 2011.

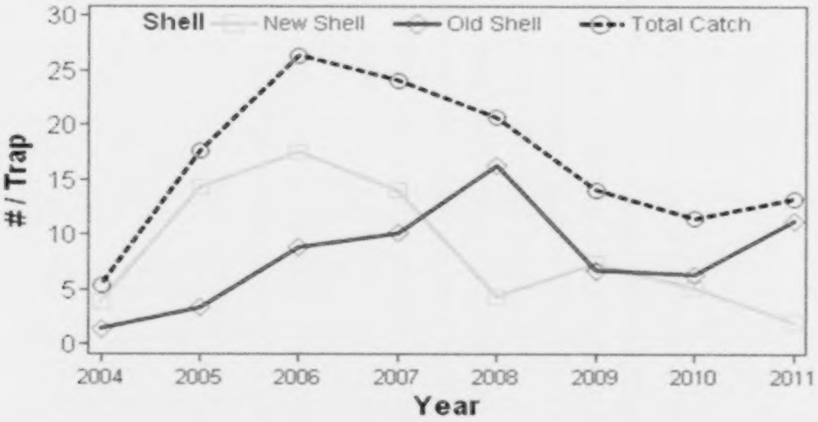


Figure 118: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 3BC.

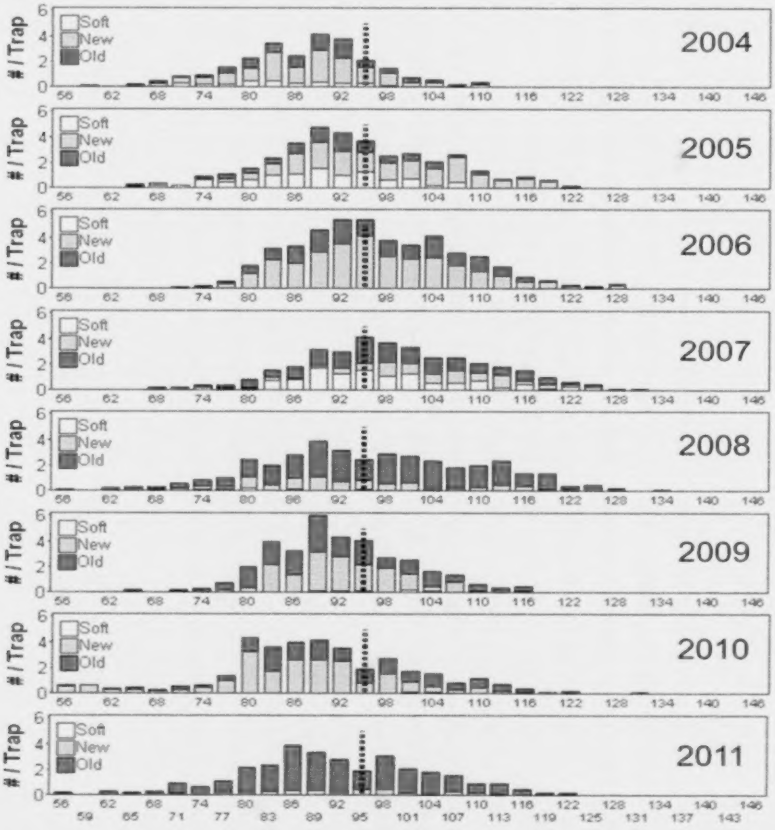


Figure 119: Trends in male carapace width distributions from core stations in Crab Management Area (CMA) 3D from the Collaborative Post-Season (CPS) survey. The vertical dashed line indicates the minimum legal size.

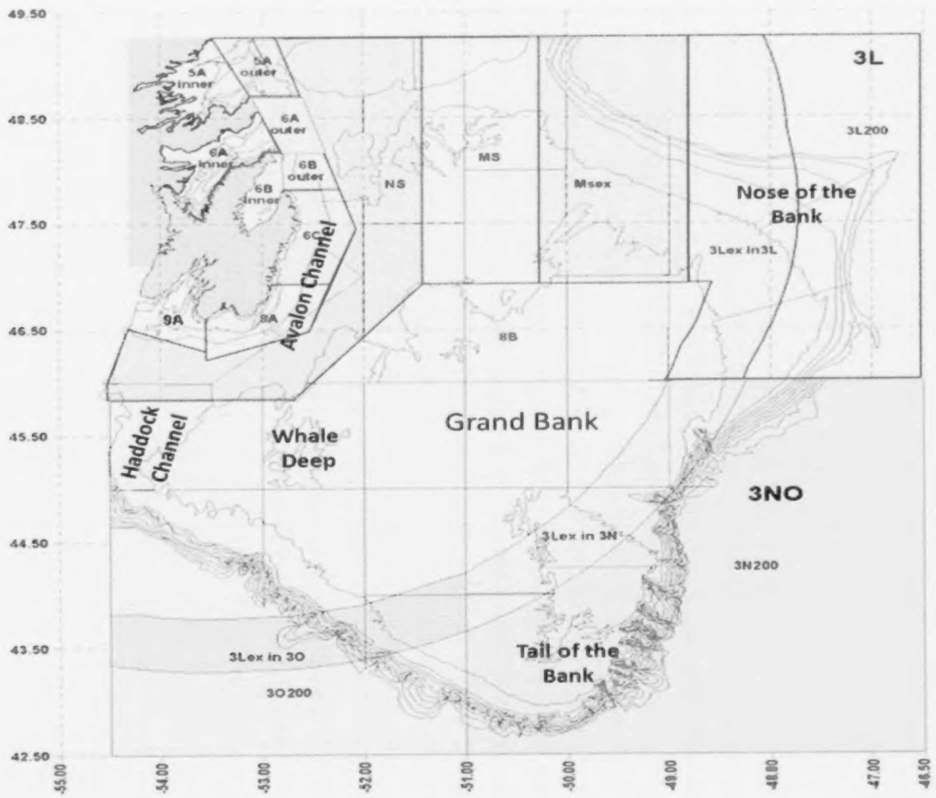

49.50
48.50
47.50
46.50
45.50
44.50
43.50
42.50
-55.00
-54.00
-53.00
-52.00
-51.00
-50.00
-49.00
-48.00
-47.00
-46.50
5A inner
5A outer
6A outer
6A inner
6B outer
6B inner
6C
9A
8A
Avalon Channel
NS
MS
Msex
8B
3L
3L200
Nose of the Bank
3Lex in3L
Haddock Channel
Whale Deep
Grand Bank
3NO
3Lex in 3N
3N200
3Lex in 3O
3O200
Tail of the Bank

Figure 120: Map of Div. 3LNO showing Crab Management Areas (CMA) and important bathymetric features.

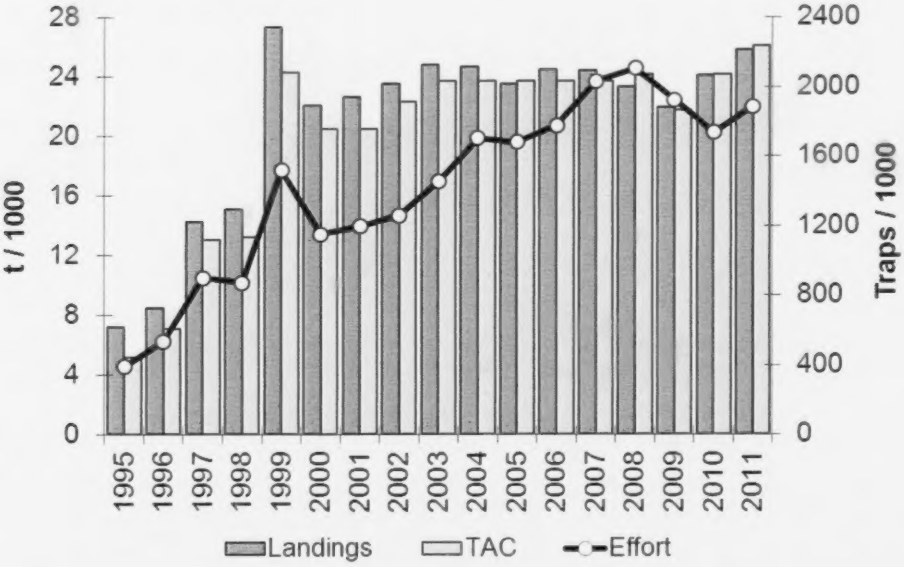


Figure 121: Trends in Div. 3LNO offshore landings, total allowable catch (TAC), and fishing effort.

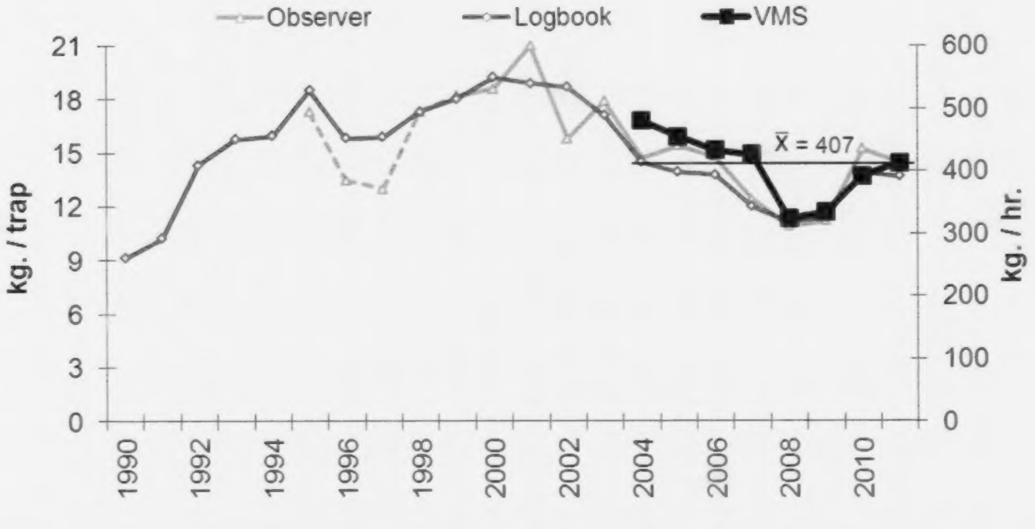


Figure 122: Trends in commercial logbook-based, observer-based, and VMS-based catch per unit effort (CPUE) in the Div. 3LNO offshore fishery. Solid black line denotes long-term VMS CPUE average.

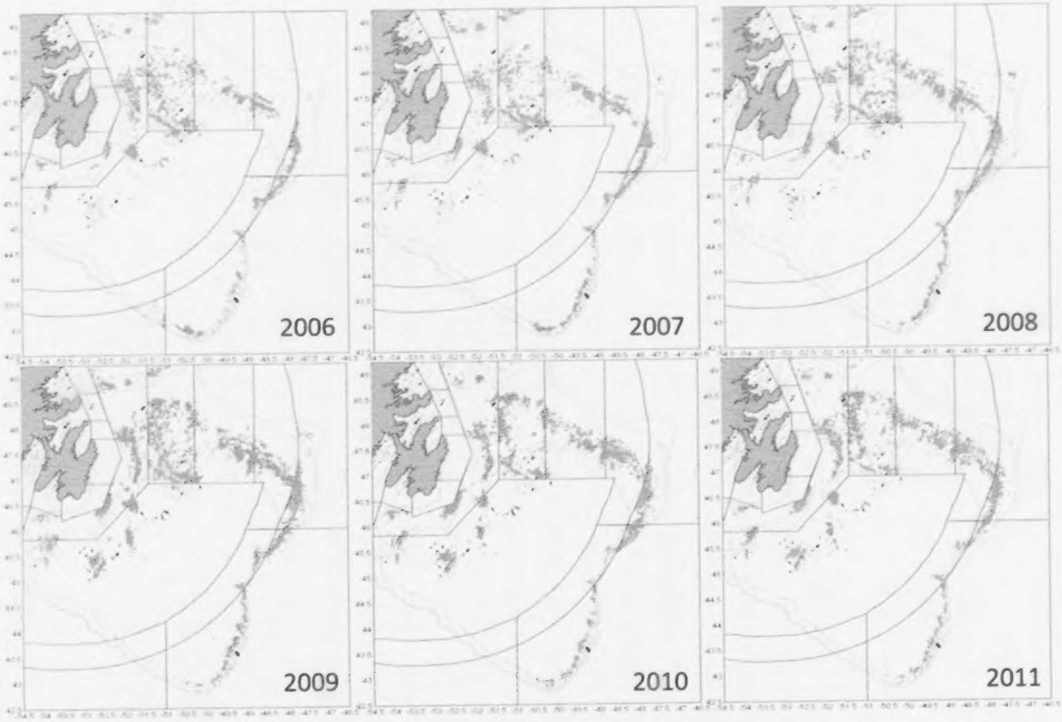

2006
2007
2008
2009
2010
2011

Figure 123: Spatial distribution of Div. 3LNO offshore fishing effort by year.

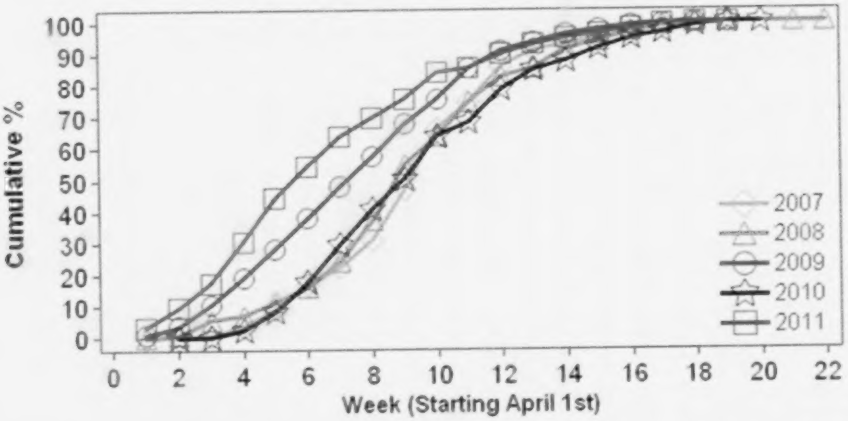


Figure 124: Seasonal trends in fishing effort for Div. 3LNO offshore during 2007-2011.

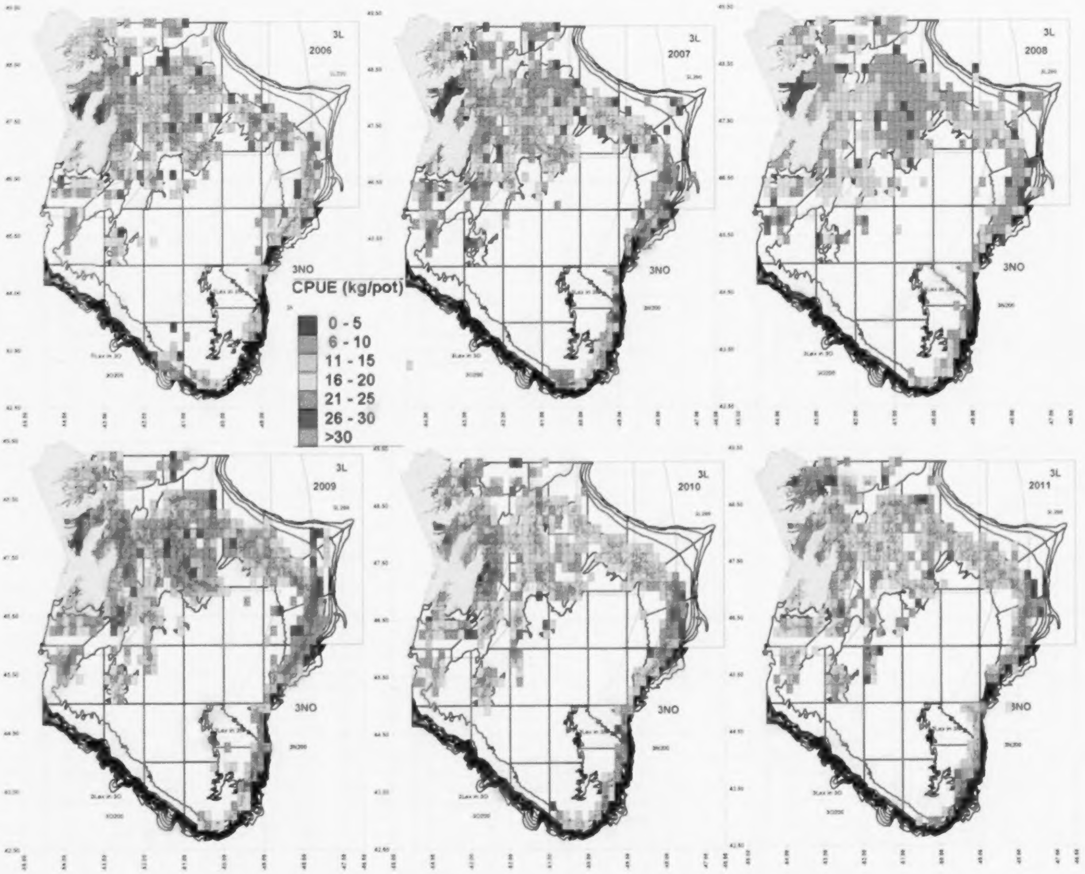

3L
2006
2007
2008
2009
2010
2011
3NO
CPUE (kg/pot)
0 - 5
6 - 10
11 - 15
16 - 20
21 - 25
26 - 30
>30

Figure 125: Spatial distribution of Div. 3LNO logbook catch per unit effort (CPUE) by year.

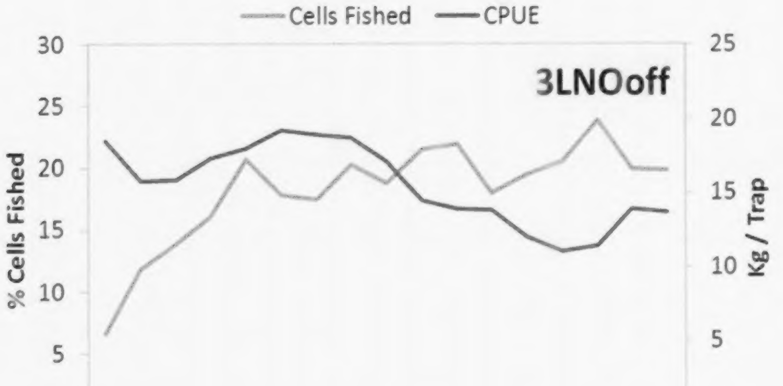


Figure 126: Trends in Div. 3LNO offshore commercial catch per unit effort (CPUE) vs. the percentage of 5' x 5' cells fished.

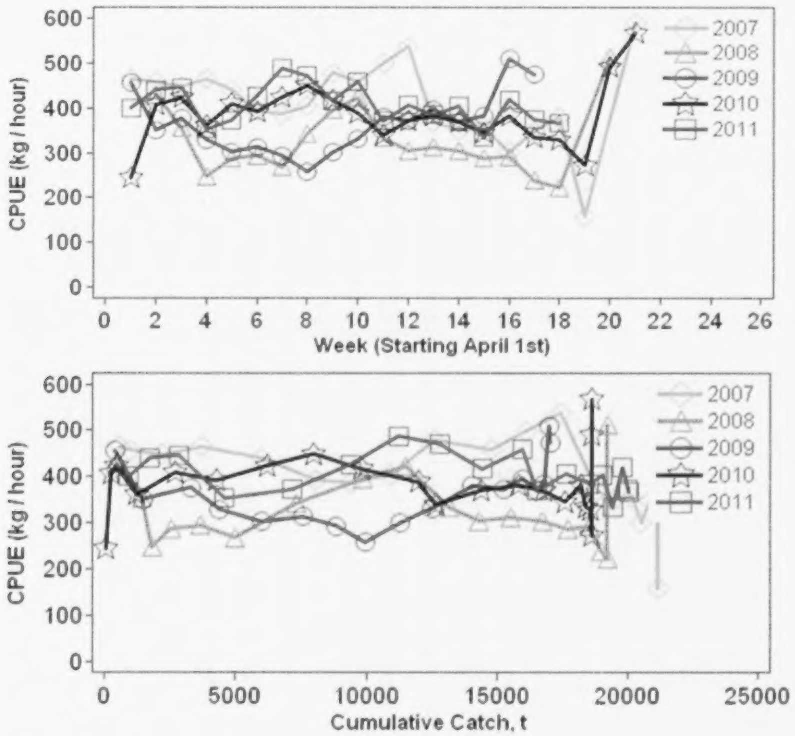


Figure 127: Seasonal trends in VMS-based catch per unit effort (CPUE) for Div. 3LNO offshore during 2007-2011; by week (above), and in relation to cumulative catch (below).

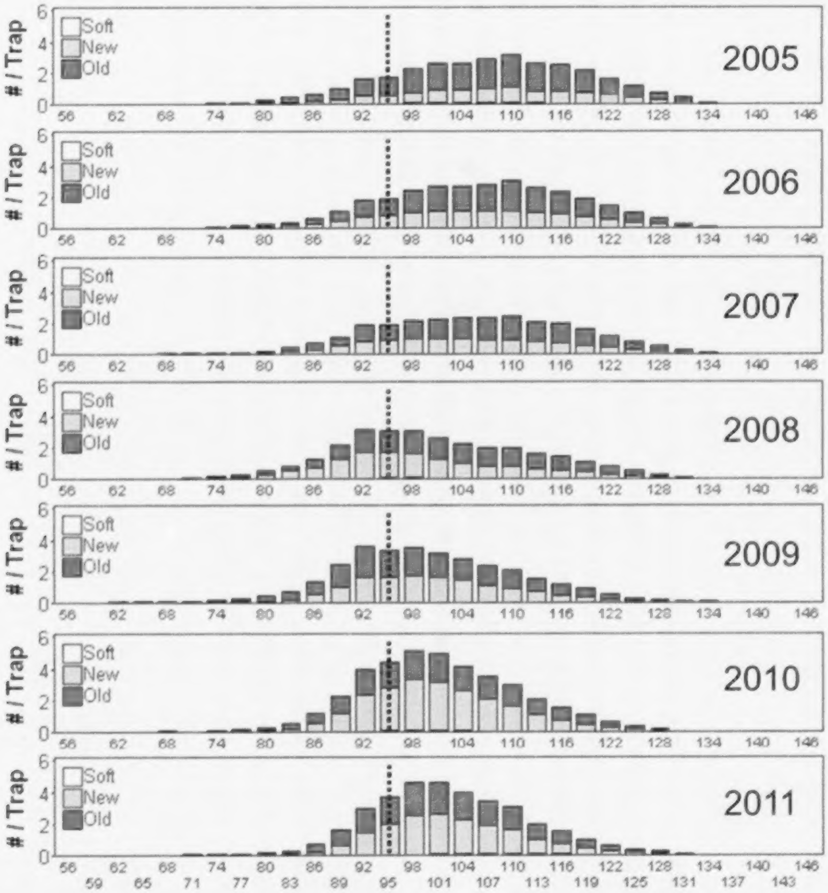


Figure 128: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Div. 3LNO offshore. The vertical dashed line indicates the minimum legal size.

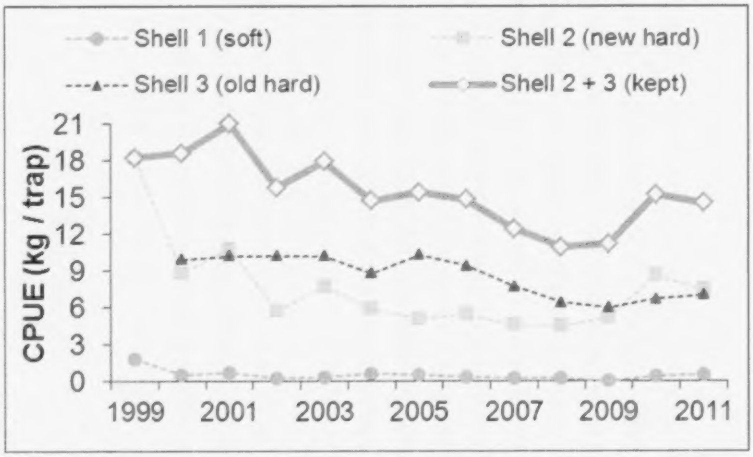


Figure 129: Trends in Div. 3LNO offshore observer catch rates of exploitable crabs by shell condition category from at-sea sampling.

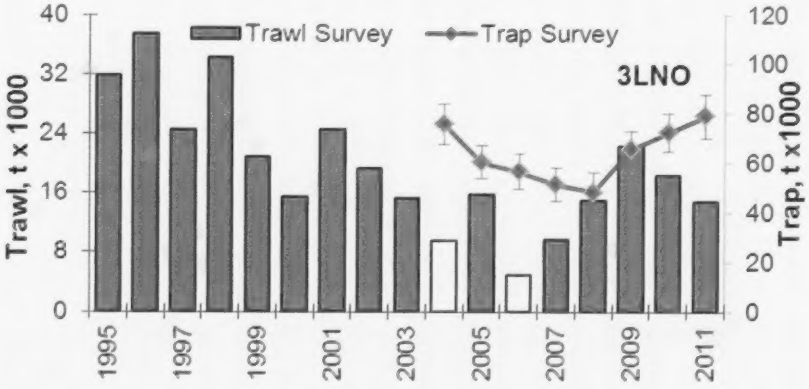


Figure 130: Trends in the Div. 3LNO offshore fall trawl survey exploitable biomass index and the Collaborative Post-Season (CPS) trap survey biomass index. The trawl survey was incomplete in 2004 and 2006.

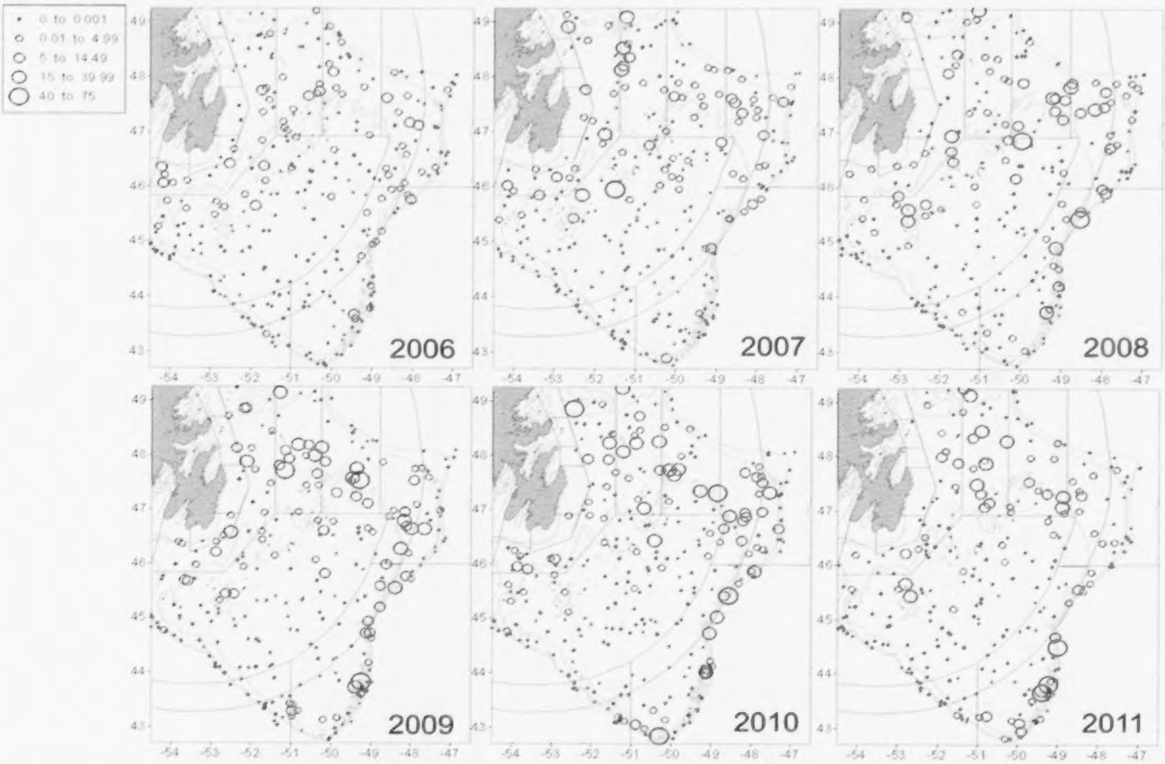

0 to 0.001
0.01 to 4.99
5 to 14.49
15 to 39.99
40 to 75
2006
2007
2008
2009
2010
2011
49
48
47
46
45
44
43
-54
-53
-52
-51
-50
-49
-48
-47

Figure 131. Spatial distribution of catches (number / set) of exploitable snow crab in the Div. 3LNO offshore trawl survey.

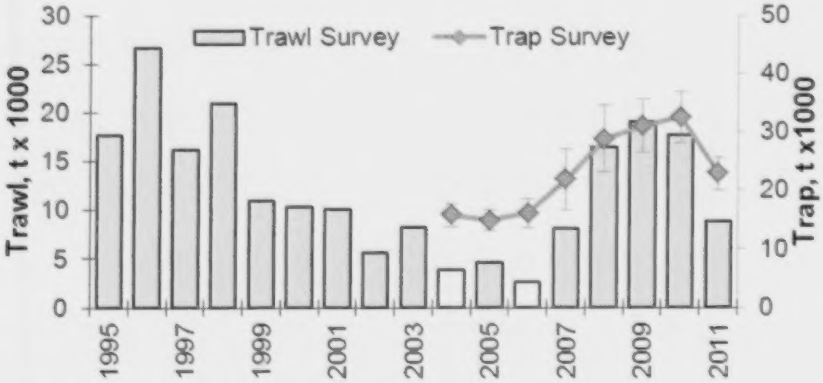
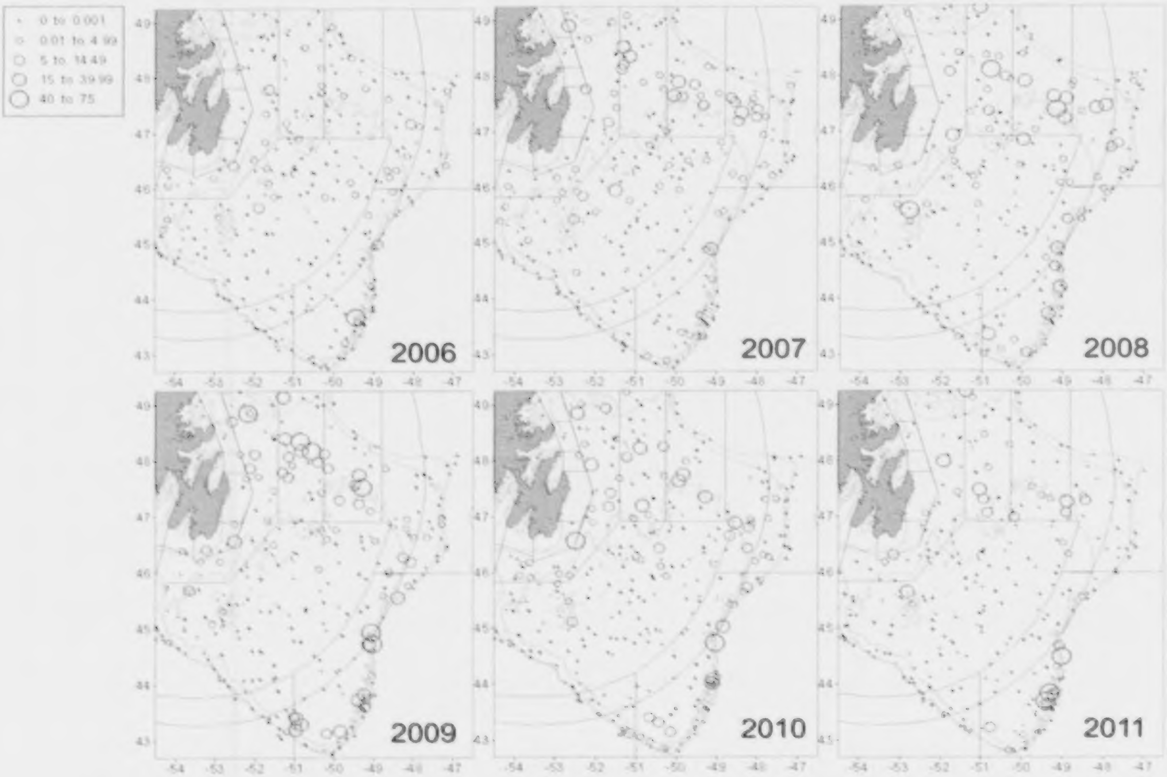


Figure 132: Trends in the Div. 3LNO offshore fall trawl survey pre-recruit biomass index and the Collaborative Post-Season (CPS) trap survey biomass index. The trawl survey was incomplete in 2004 and 2006.


0 to 0.001
0.01 to 4.99
5 to 14.49
15 to 39.99
40 to 75
2006
2007
2008
2009
2010
2011
49
48
47
46
45
44
43
-54
-53
-52
-51
-50
-49
-48
-47

Figue 133. Spatial distribution of catches (number / set) of pre-recruit snow crab in the Div. 3LNO offshore trawl survey.

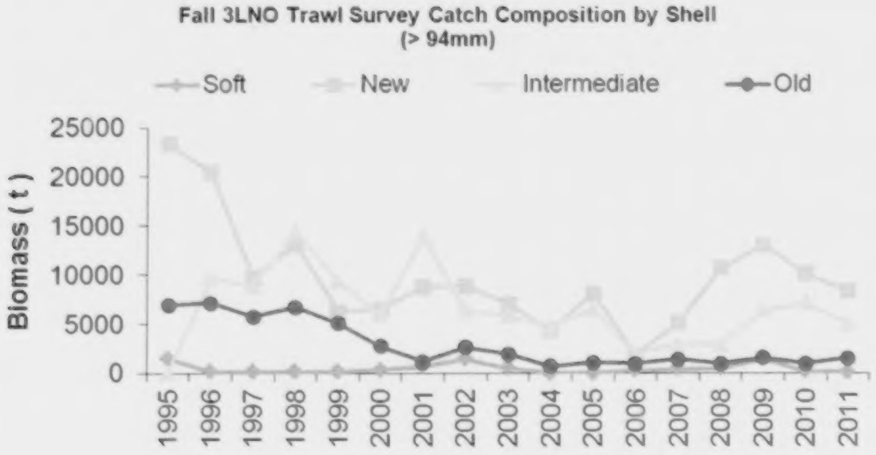


Figure 134: Trends, by shell condition, in biomass of legal-sized males for Div. 3LNO offshore from fall trawl surveys.

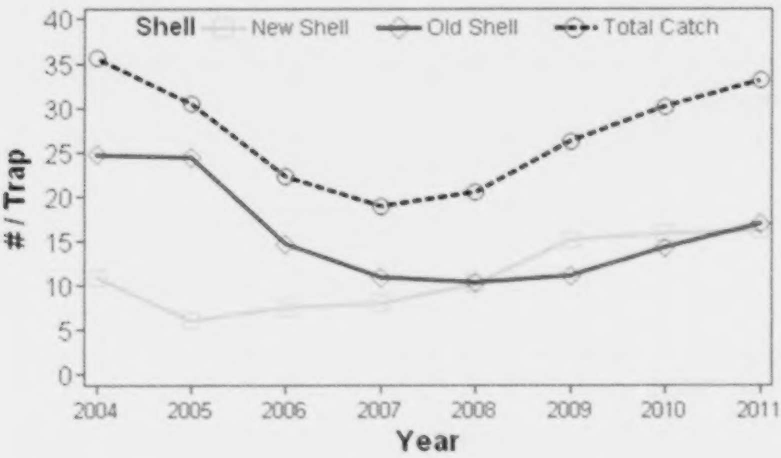


Figure 135: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Div. 3LNO offshore Collaborative Post-Season (CPS) trap survey.

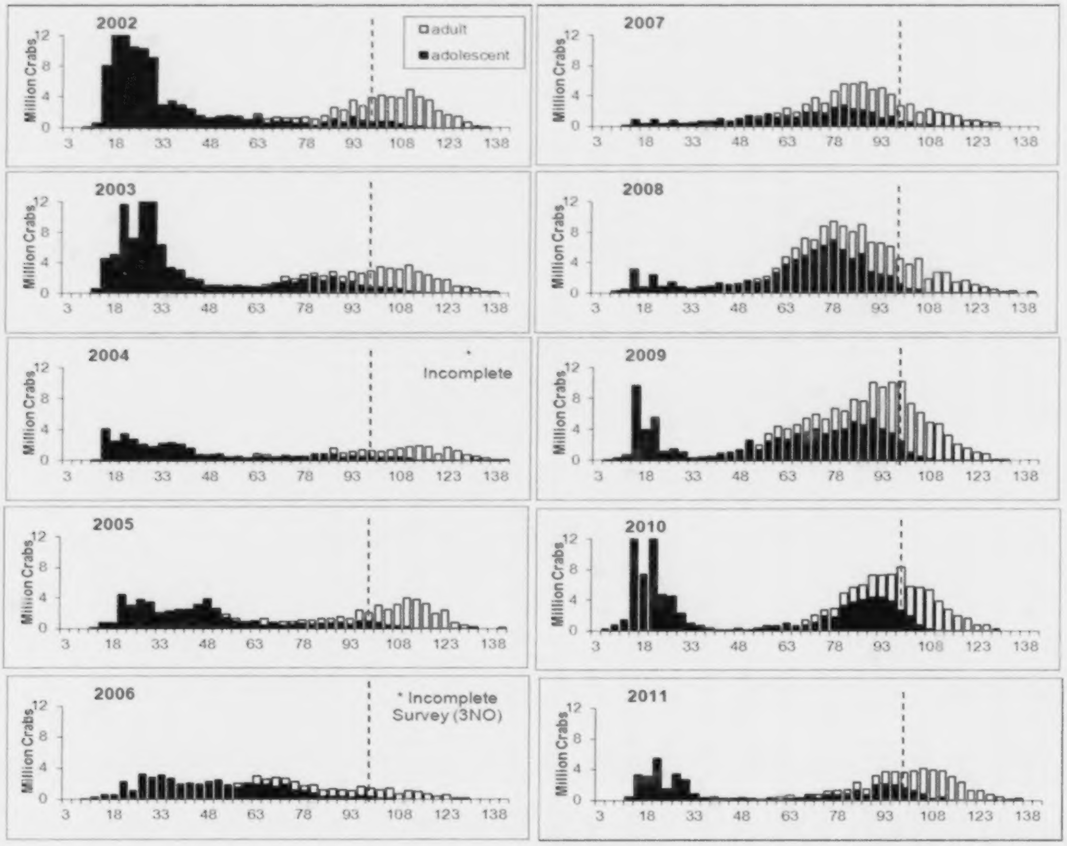


Figure 136: Abundance indices by carapace width for Div. 3LNO juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys.

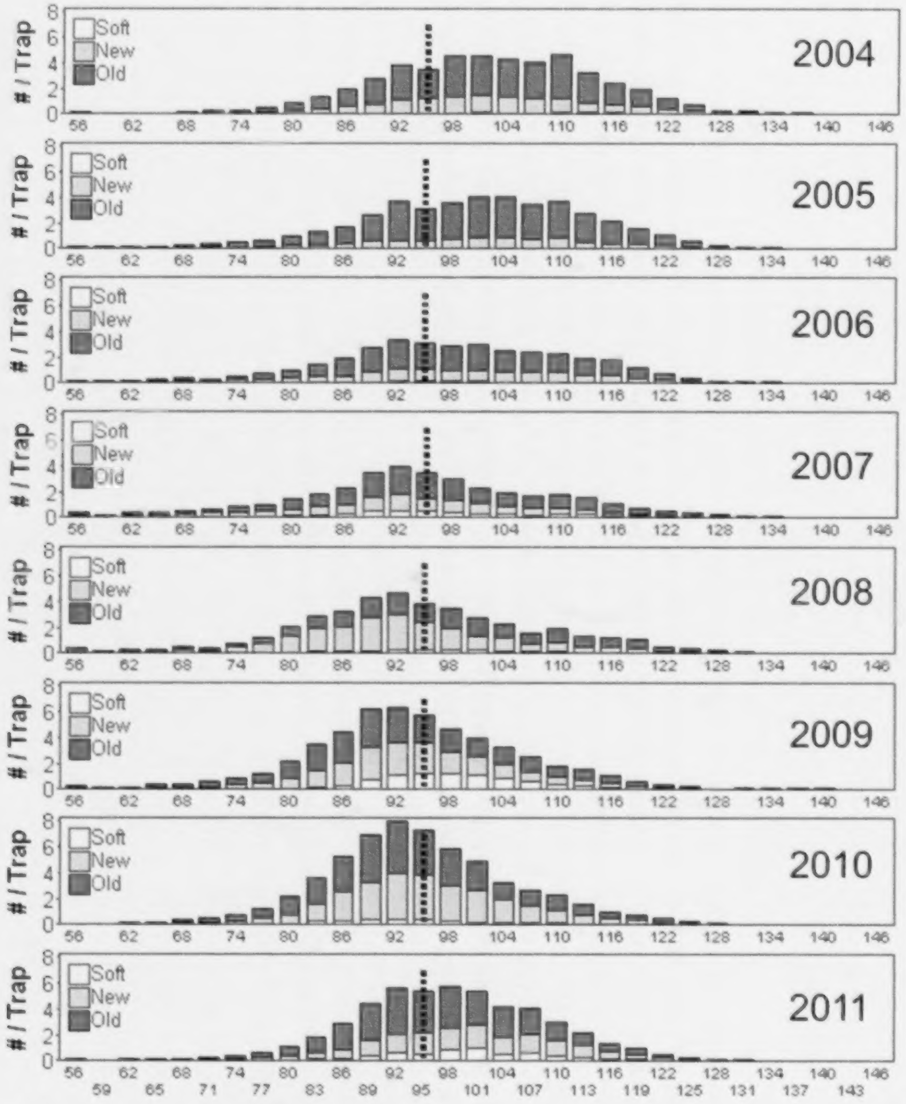


Figure 137: Trends in male carapace width distributions from core stations in the Div. 3LNO offshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

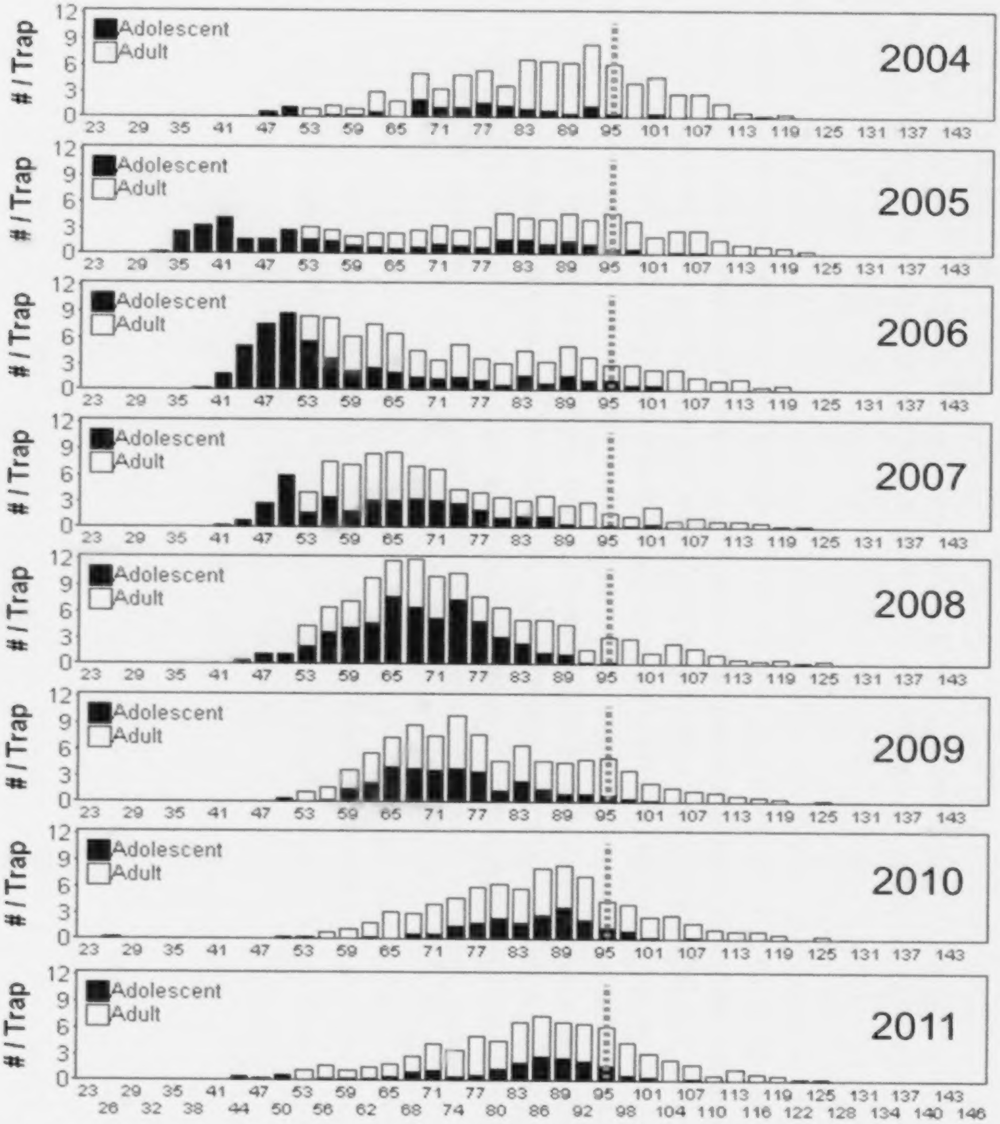


Figure 138: Trends in male carapace width distributions from small-mesh traps in the Div. 3LNO offshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

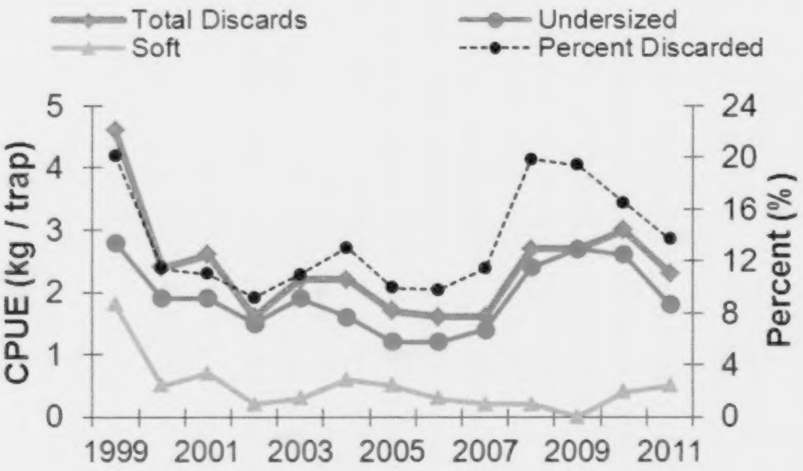
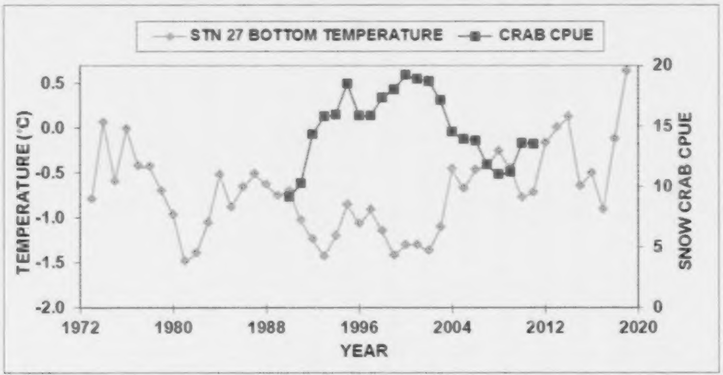


Figure 139: Trends in Div. 3LNO offshore observer catch rates of total discards, under-sized discards, and legal-sized discards, as well as the percentage of the catch discarded.



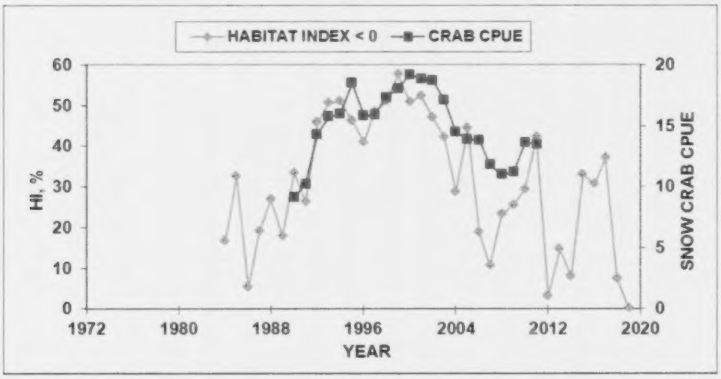


Figure 140: Trends in the Div. 3LNO offshore catch per unit effort (CPUE) vs. bottom temperature at an eight year lag (above) and vs. the spatial extent of <0 degree water (below).

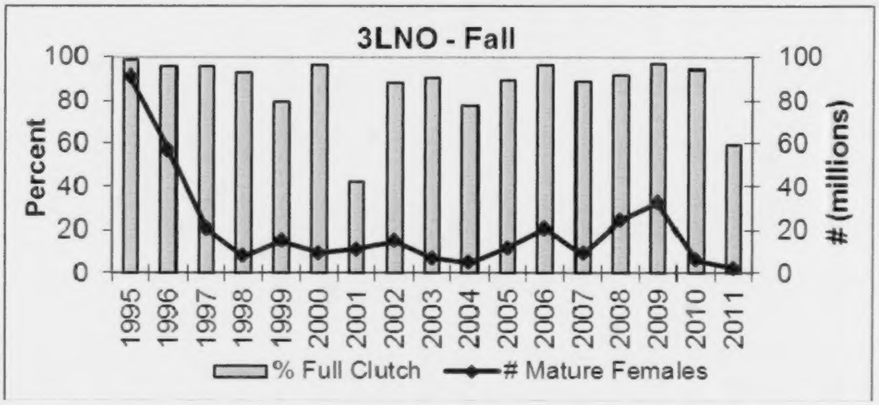


Figure 141: Trends in mature female abundance and percentage bearing full clutches of viable eggs in Div. 3LNO from fall multi-species surveys.

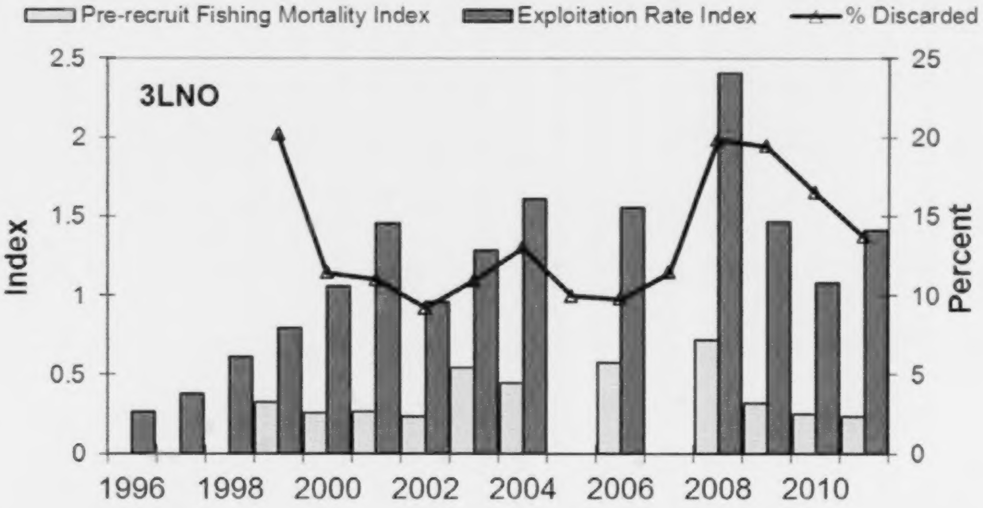


Figure 142: Trends in Div. 3LNO offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery (no 2005 or 2007 exploitation rate or pre-recruit fishing mortality indices because of incomplete 2004 and 2006 surveys).

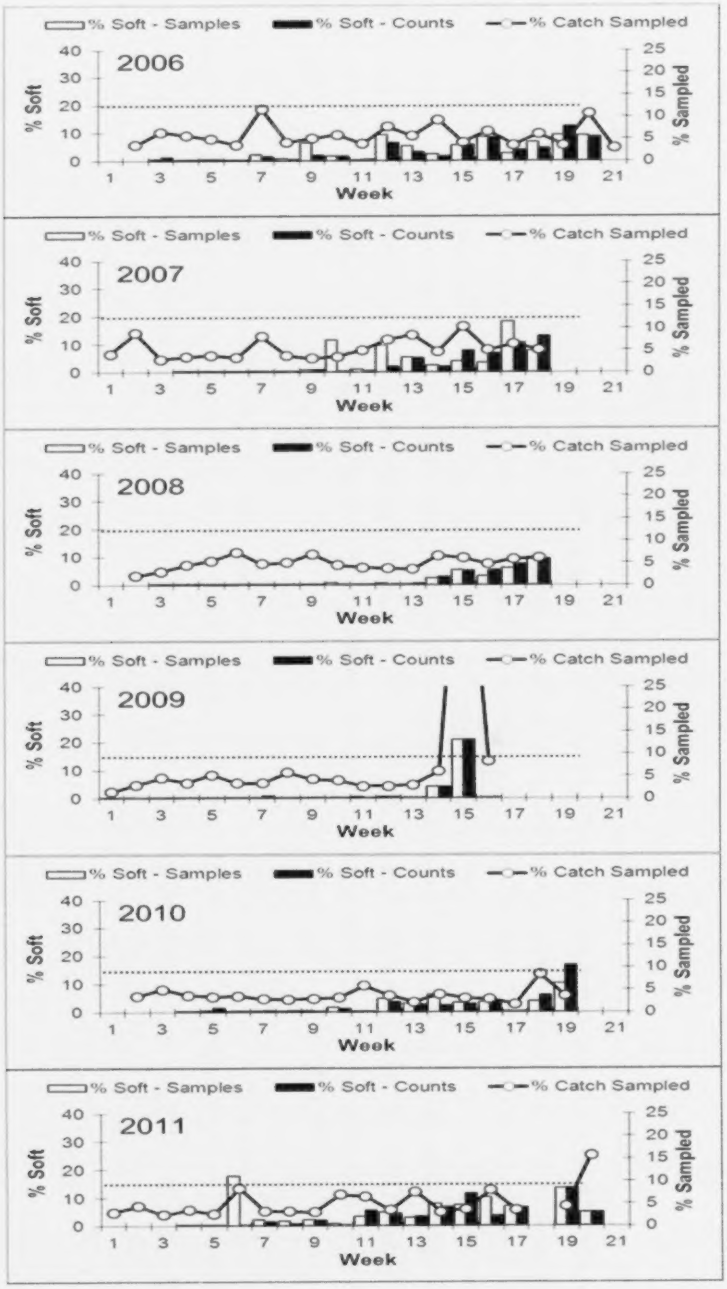


Figure 143: Trends in weekly percentages of soft-shell crab monitored and sampled in Div. 3LNO offshore from 2006 to 2011.

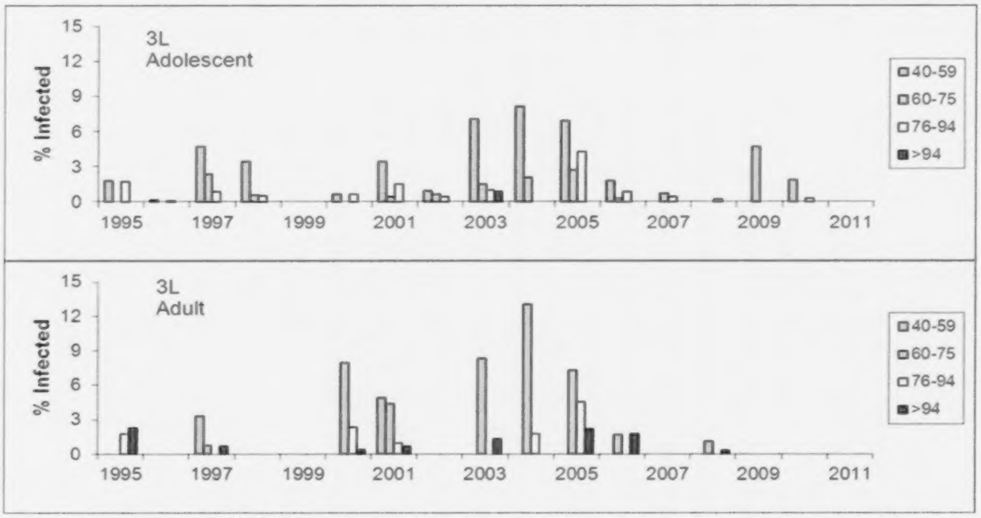


Figure 144: Trends in prevalence of Bitter Crab Disease (BCD) in new-shelled adolescents (above) and adults (below) by male size group from Div. 3L fall trawl surveys.

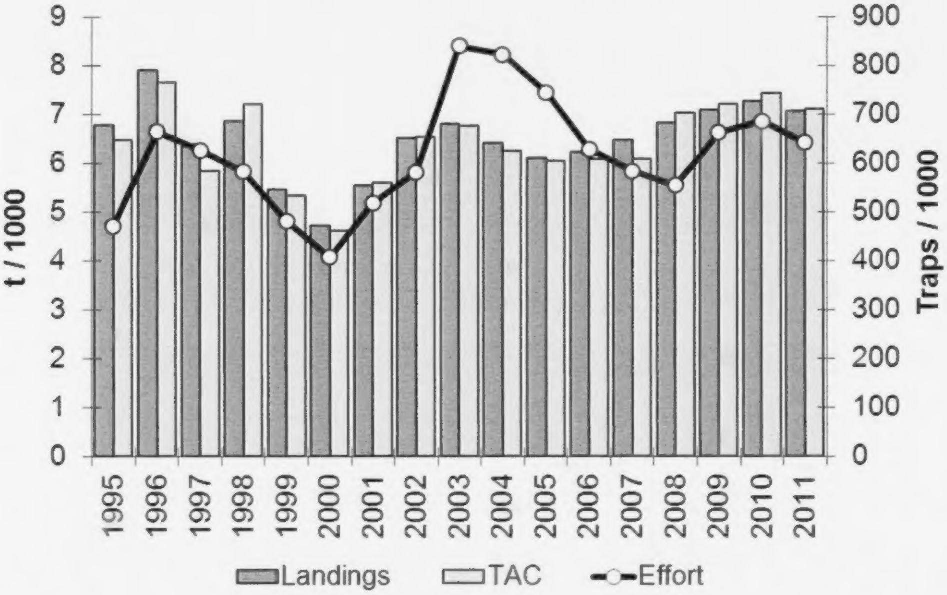


Figure 145: Trends in Div. 3L inshore landings, total allowable catch (TAC), and fishing effort.

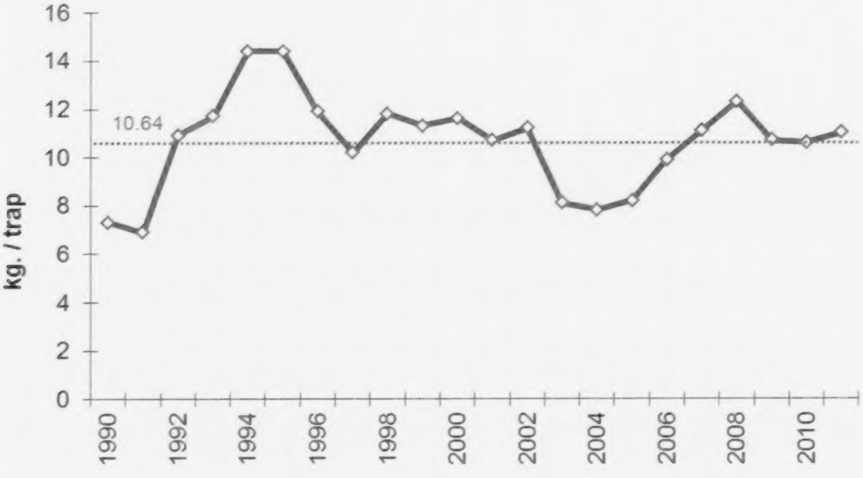


Figure 146: Trends in commercial logbook-based catch per unit effort (CPUE) in the Div. 3L inshore fishery.

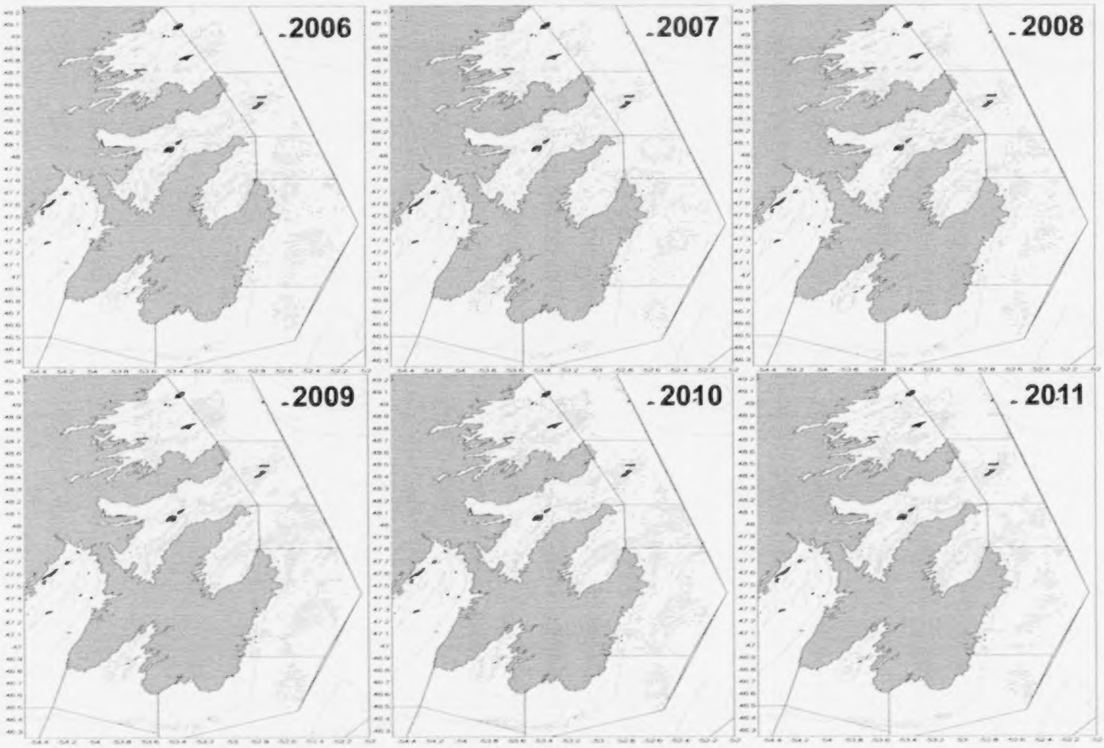

2006
2007
2008
2009
2010
2011

Figure 147: Spatial distribution of Div. 3L inshore fishing effort by year.

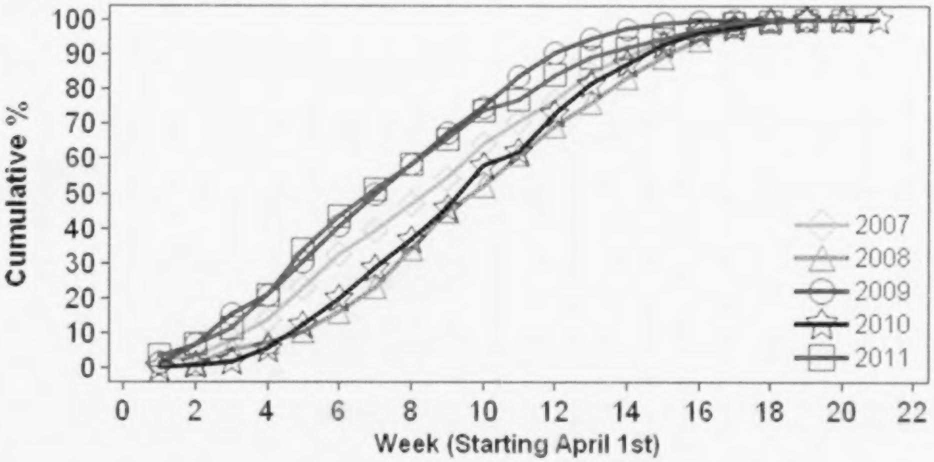


Figure 148: Seasonal trends in weekly fishing effort for Div. 3L inshore during 2007-2011.

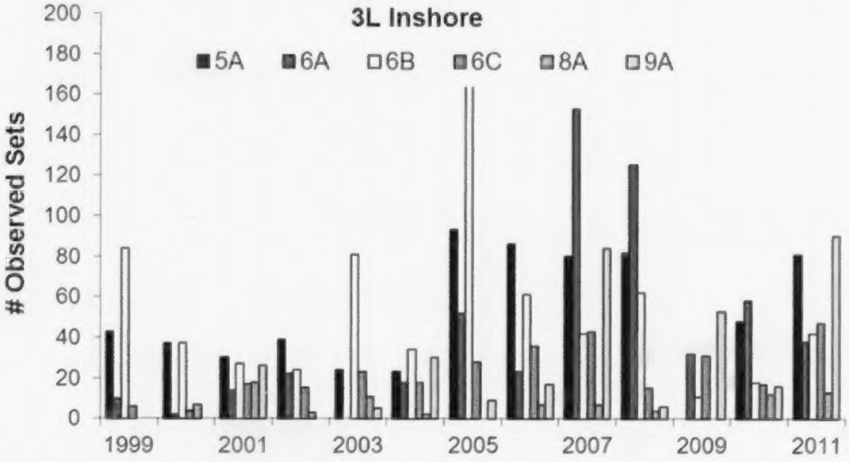


Figure 149: Trends in number of observed sets by Crab Management Areas (CMA) and year in Div. 3L inshore.

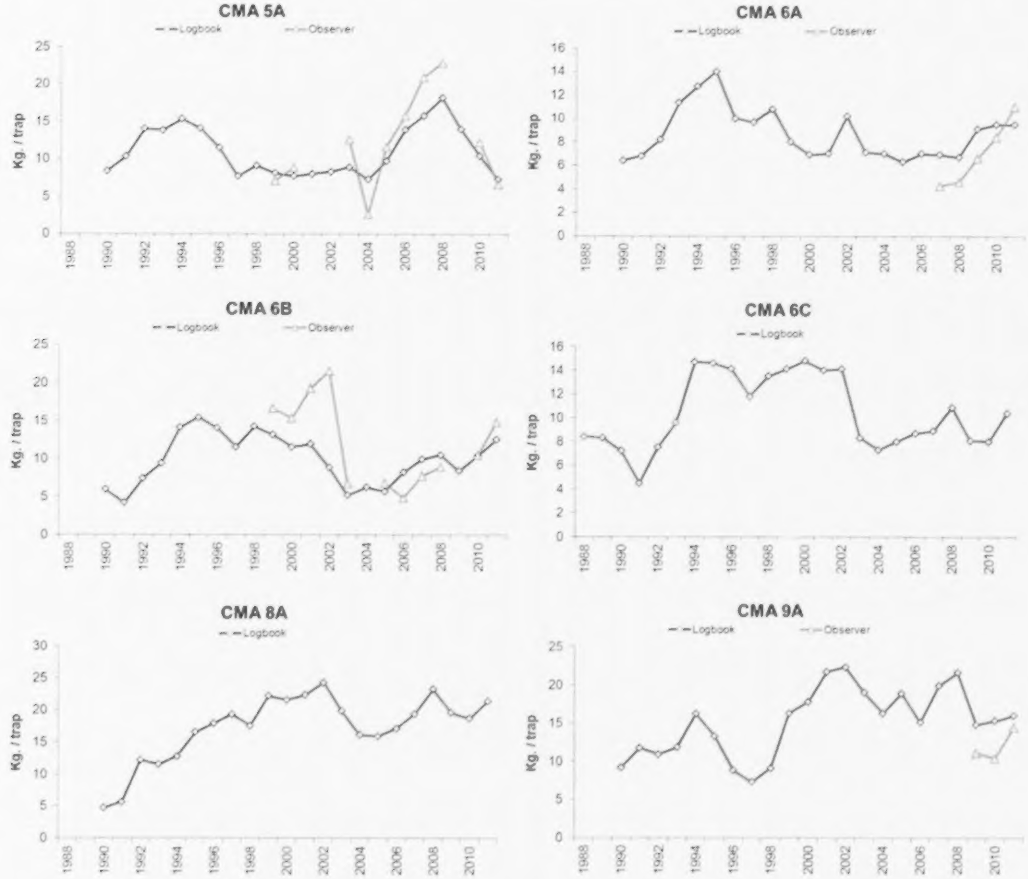


Figure 150: Trends in Div. 3L inshore logbook catch per unit effort (CPUE) and observer CPUE by Crab Management Area (CMA).

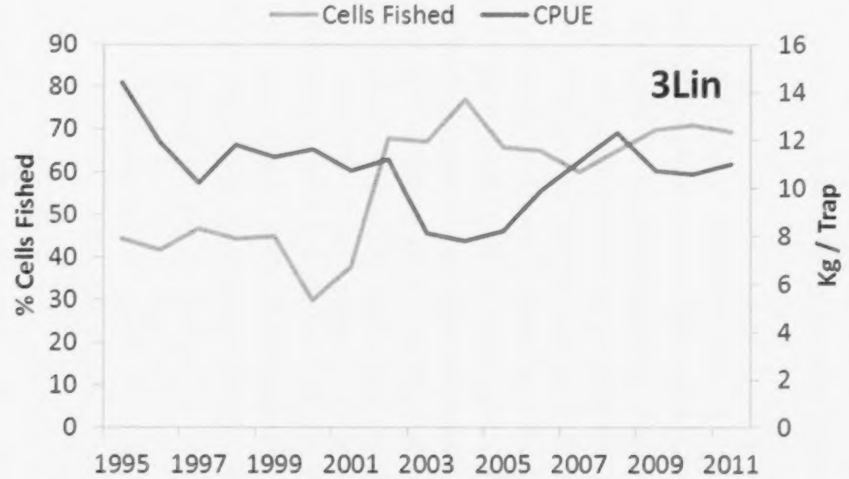


Figure 151: Trends in Div. 3L inshore commercial catch per unit effort (CPUE) vs. the percentage of 5' x 5' cells fished.

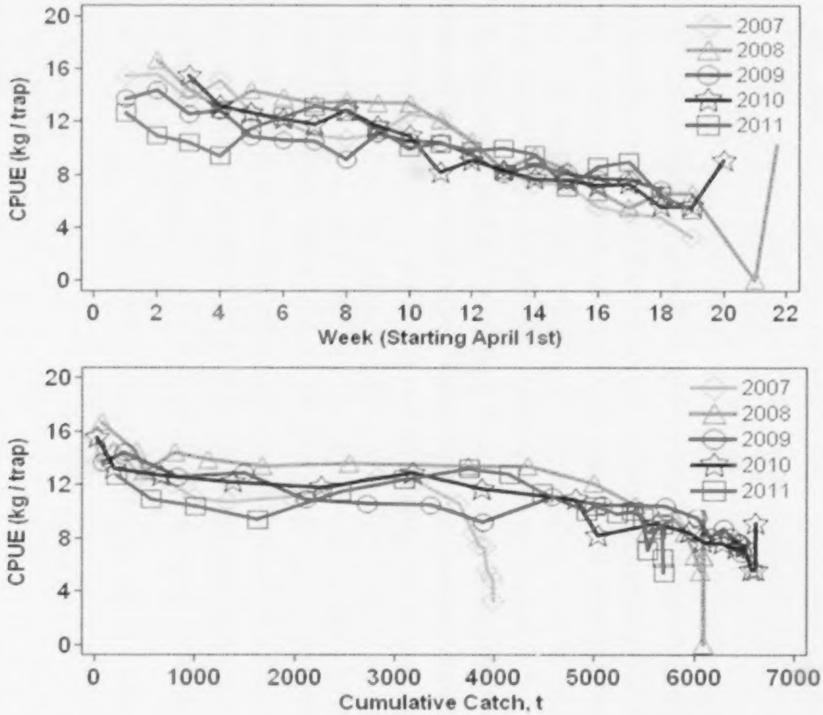


Figure 152: Seasonal trends in logbook-based catch per unit effort (CPUE) for Div. 3L inshore during 2007-2011; by week, (above) and in relation to cumulative catch (below).

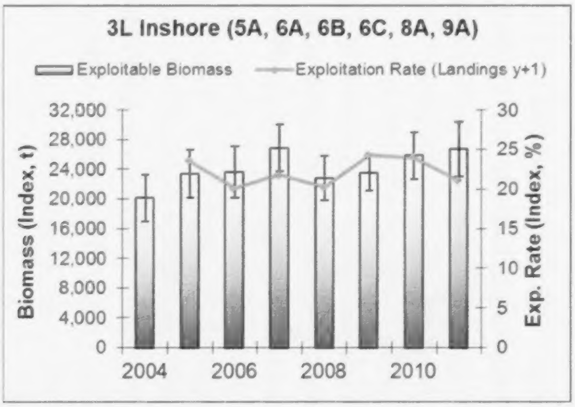


Figure 153: Exploitable biomass and exploitation rate indices from the Collaborative Post-Season (CPS) trap survey in Div. 3L inshore.

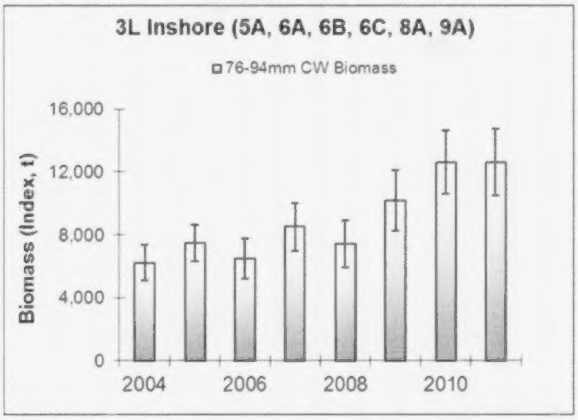


Figure 154: Pre-recruit biomass index based on the Collaborative Post-Season (CPS) trap survey in Div. 3L inshore.

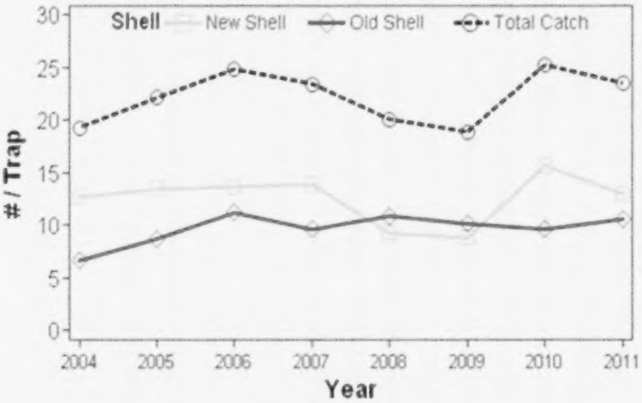


Figure 155: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Div. 3L inshore.

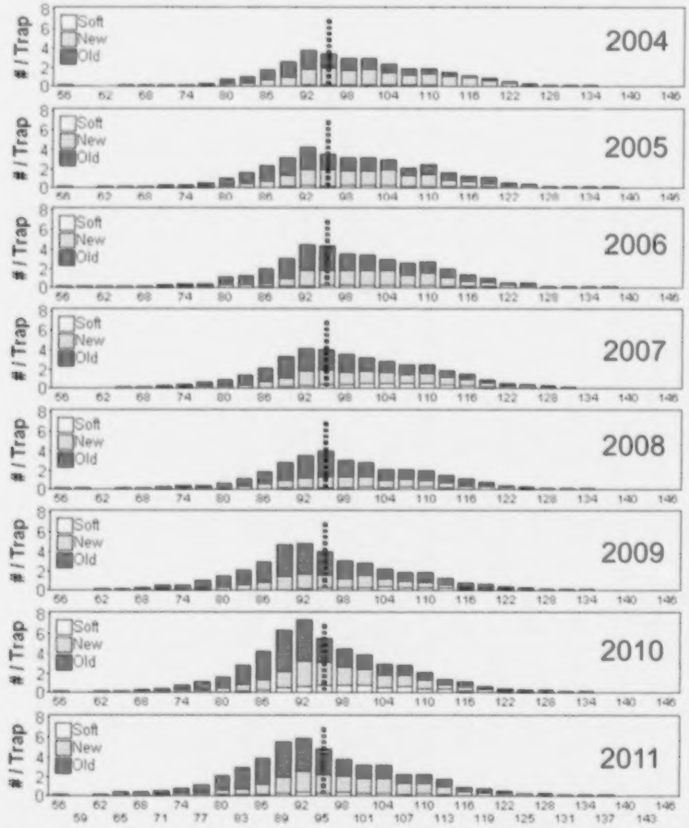


Figure 156: Trends in male carapace width distributions from core stations in the Div. 3L inshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

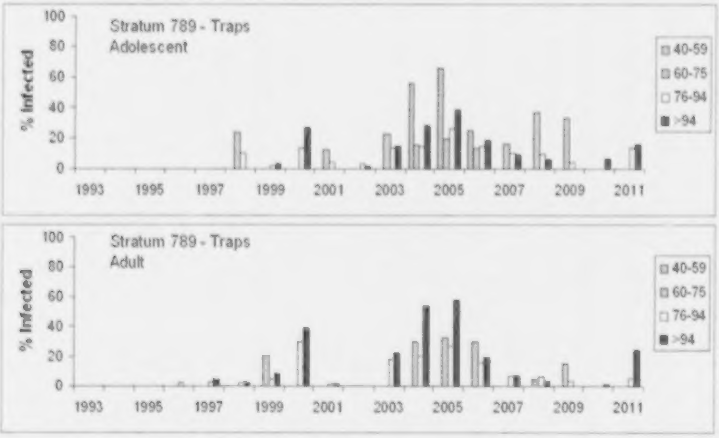


Figure 157: Trends of prevalence of Bitter Crab Disease (BCD) in new-shelled males by stratum, year, and size group from DFO trap survey in Conception Bay; adolescents (above) and adults (below).

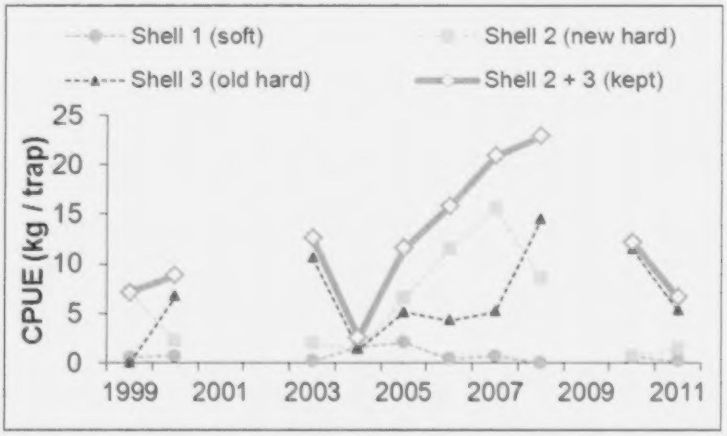


Figure 158: Trends in Crab Management Area (CMA) 5A observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

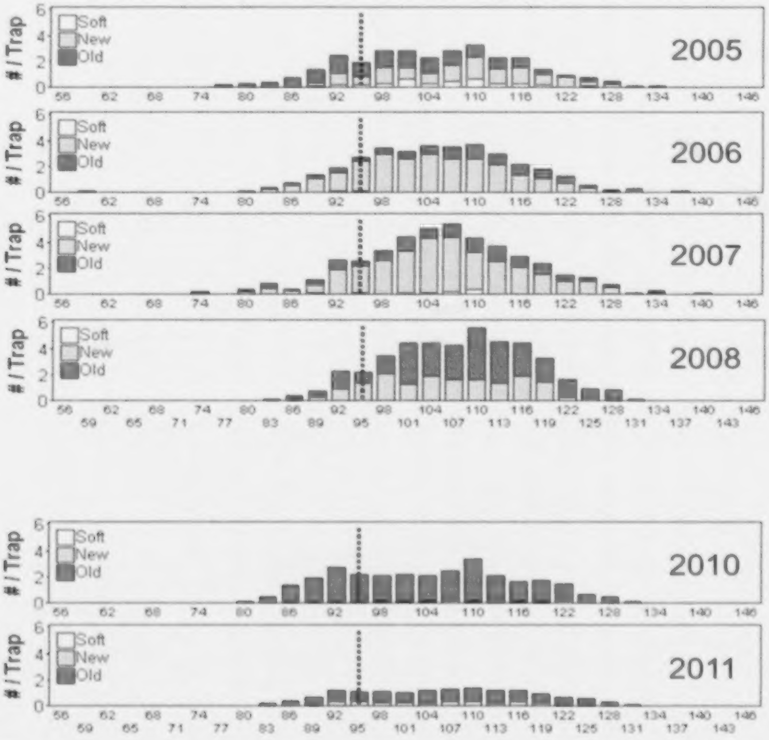


Figure 159: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Crab Management Area (CMA) 5A. The vertical dashed line indicates the minimum legal size.

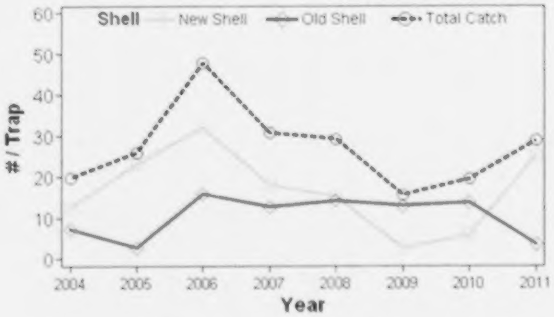


Figure 160: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 5A.

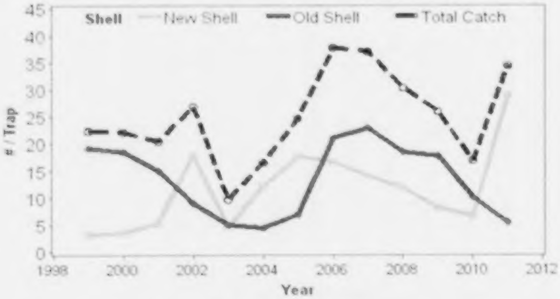


Figure 161: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from the stratum occupied in the DFO trap survey in Bonavista Bay.

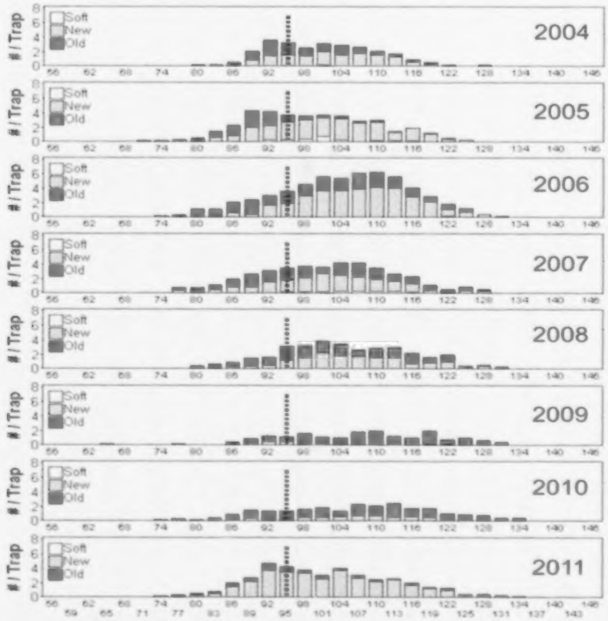


Figure 162: Trends in male carapace width distributions from core stations in Crab Management Area (CMA) 5A from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

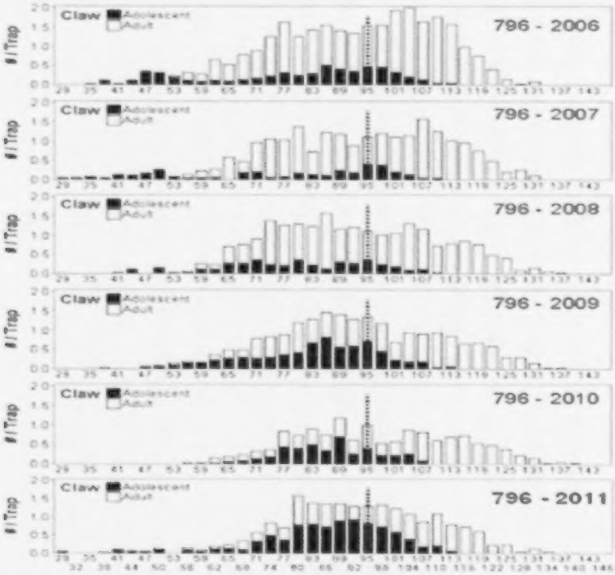


Figure 163: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in the DFO trap survey in Bonavista Bay from 2006 to 2011. The vertical dashed line indicates the minimum legal size.

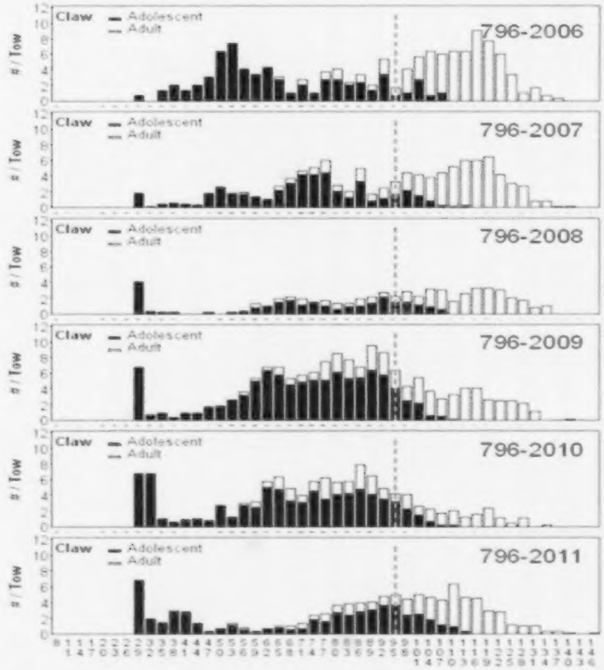


Figure 164: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from the DFO trawl survey in Bonavista Bay from 2006 to 2011. The vertical dashed line indicates the minimum legal size.

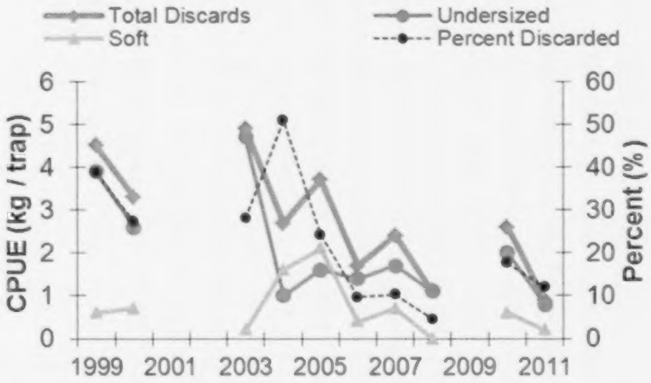


Figure 165: Trends in Crab Management Area (CMA) 5A observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

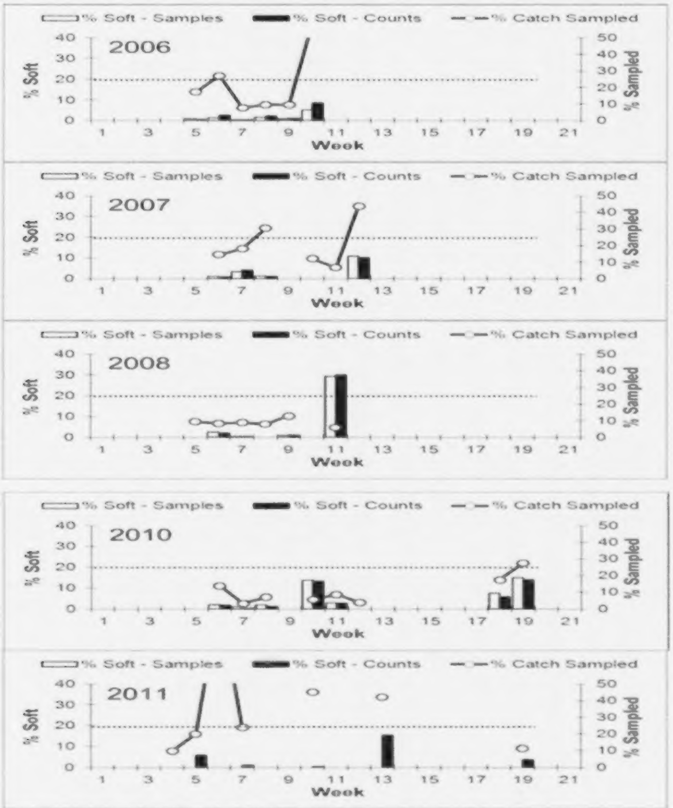


Figure 166: Trends in weekly percentages of soft-shell crab monitored and sampled in Crab Management Area (CMA) 5A from 2006 to 2011.

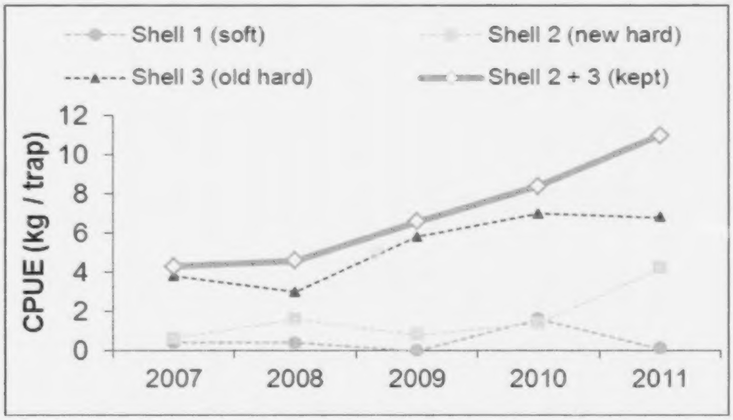


Figure 167: Trends in Crab Management Area (CMA) 6A observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

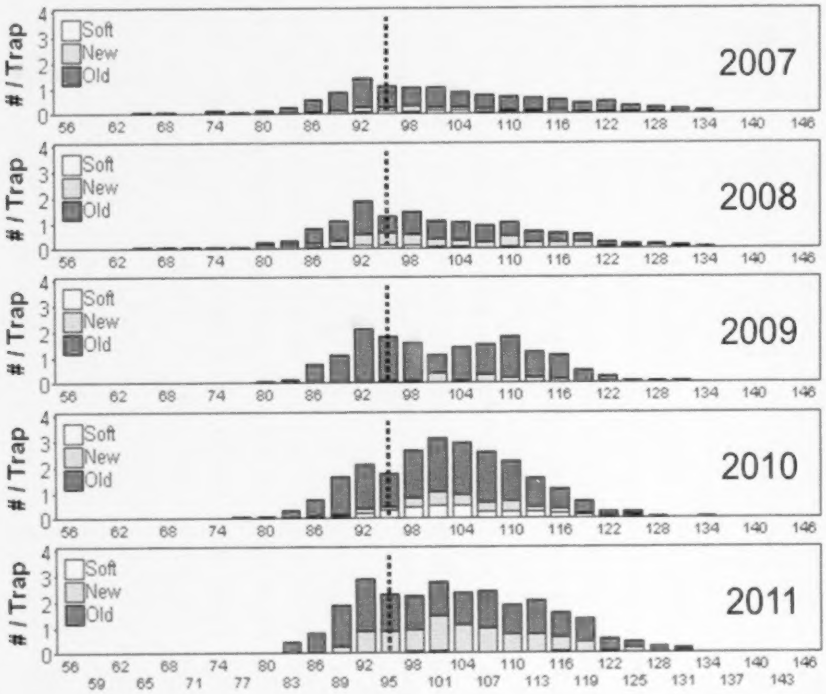


Figure 168: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Crab Management Area (CMA) 6A. The vertical dashed line indicates the minimum legal size.

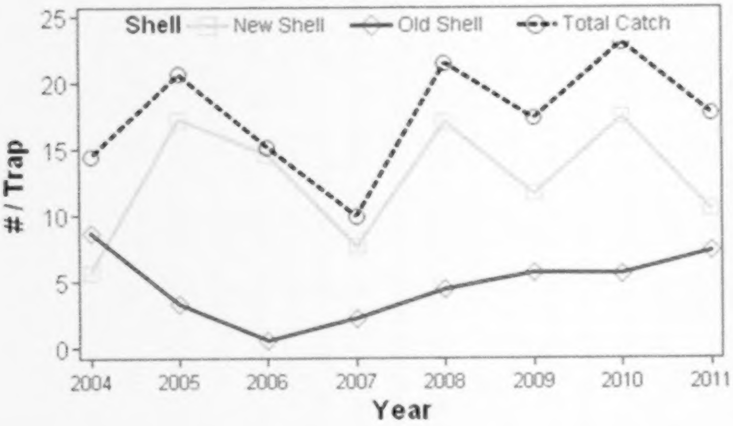


Figure 169: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 6A.

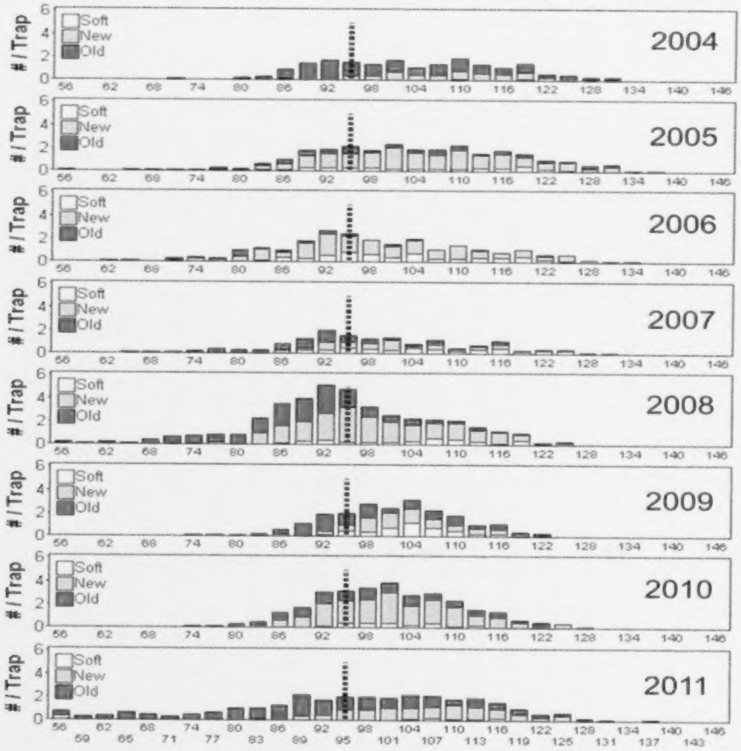


Figure 170: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 6A. The vertical dashed line indicates the minimum legal size.

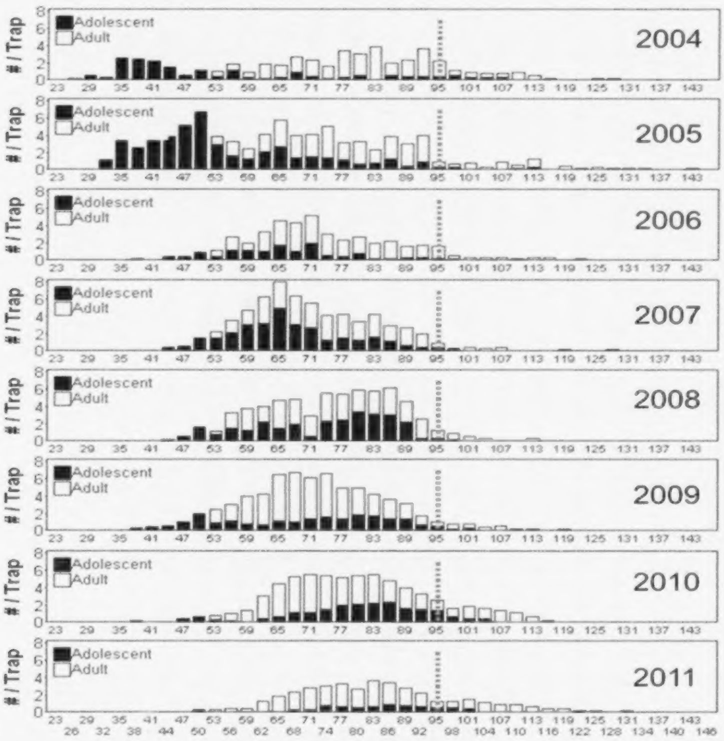


Figure 171: Trends in male carapace width distributions from small-mesh traps in Crab Management Area (CMA) 6A from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

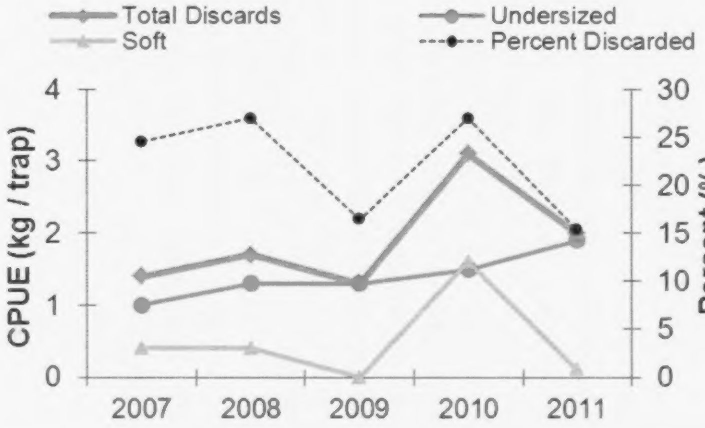


Figure 172: Trends in Crab Management Area (CMA) 6A observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

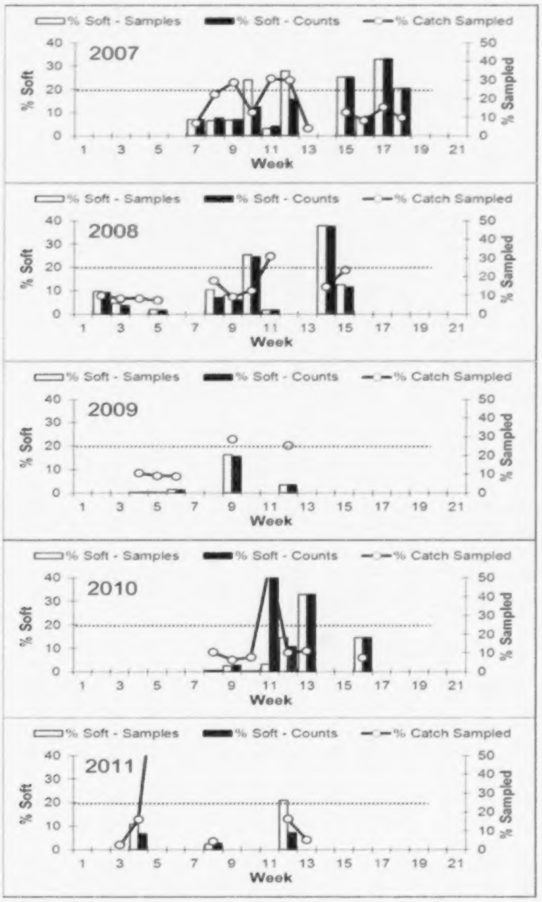


Figure 173: Trends in weekly percentages of soft-shell crab monitored and sampled in Crab Management Area (CMA) 6A from 2006 to 2011.

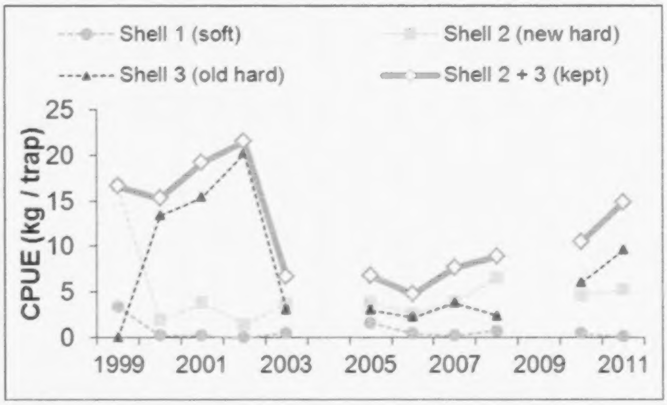


Figure 174: Trends in Crab Management Area (CMA) 6B observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

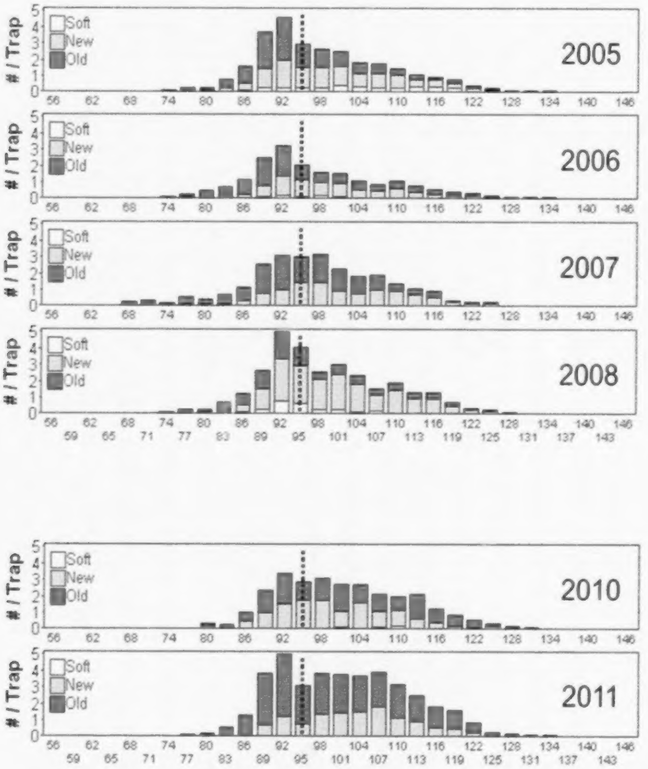


Figure 175: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Crab Management Area (CMA) 6B. The vertical dashed line indicates the minimum legal size.

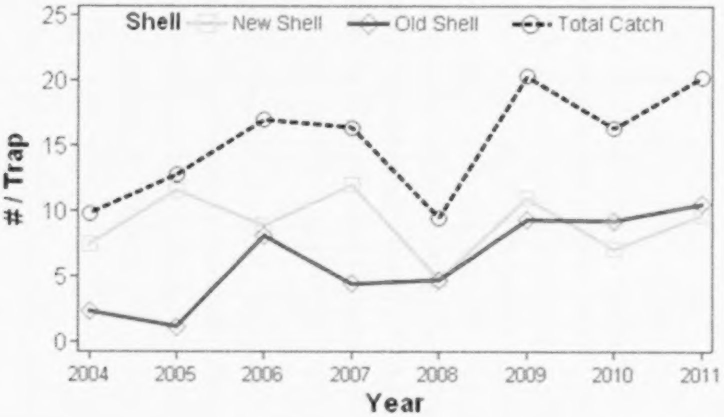


Figure 176: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 6B.

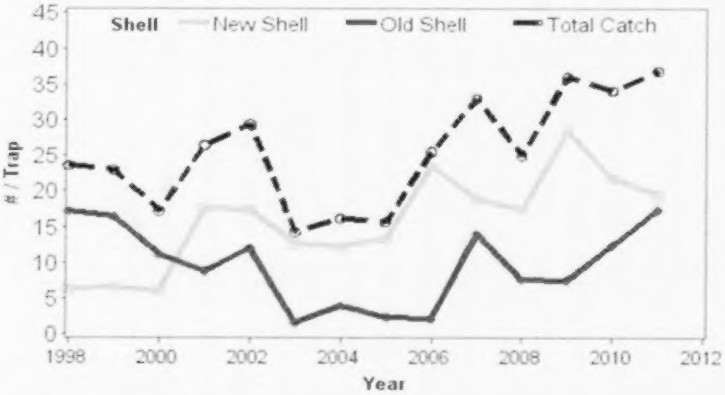


Figure 177: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from the stratum occupied in the DFO trap survey in Conception Bay.

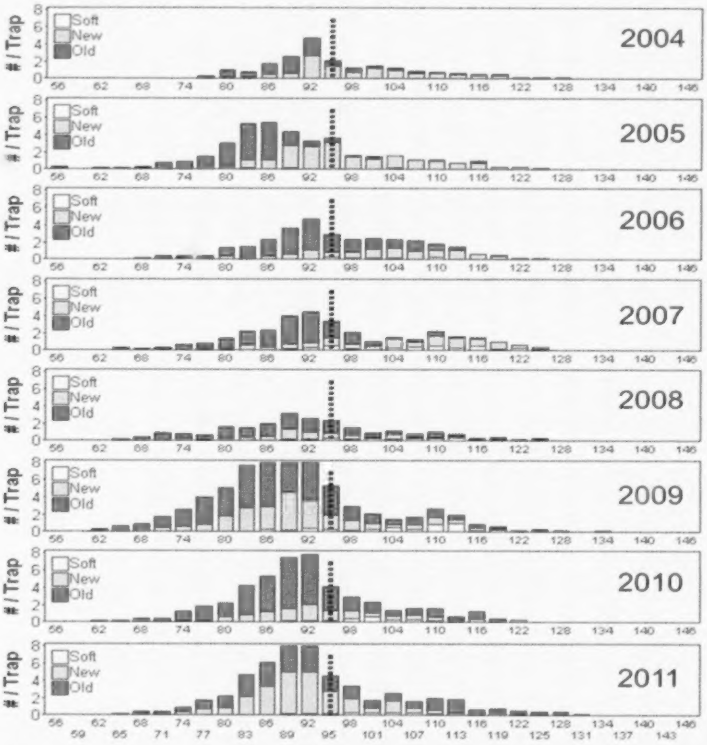


Figure 178: Trends in male carapace width distributions from core stations in Crab Management Area (CMA) 6B from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

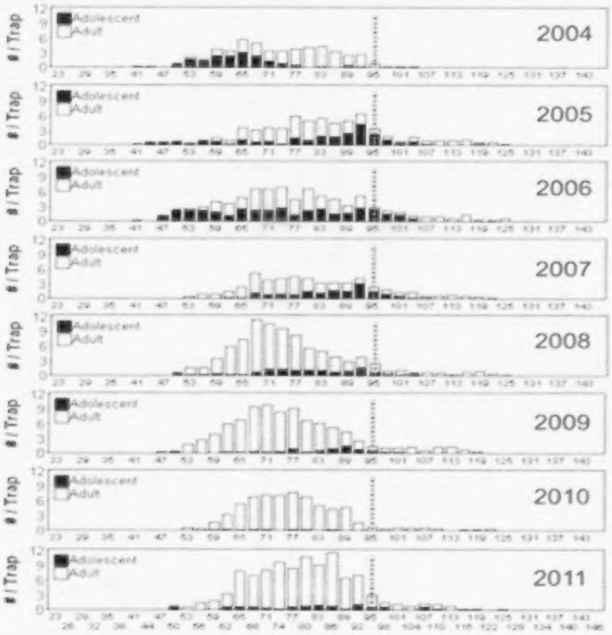


Figure 179: Trends in male carapace width distributions from small-mesh traps in Crab Management Area (CMA) 6B from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

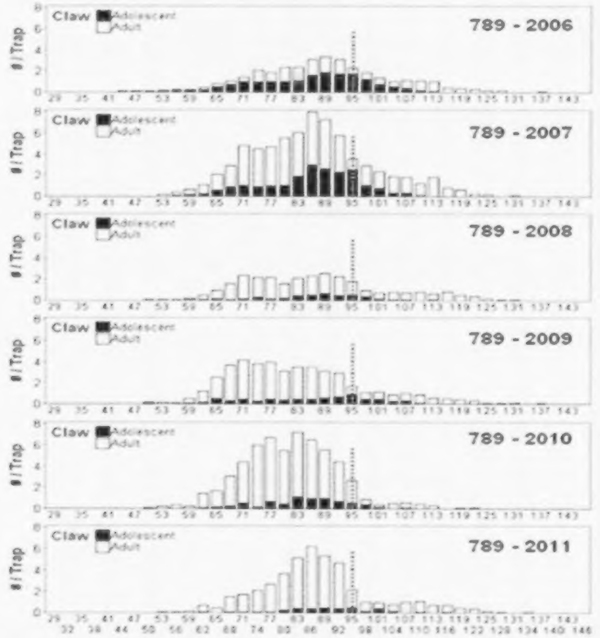


Figure 180: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in the DFO trap survey in Conception Bay from 2006 to 2011.

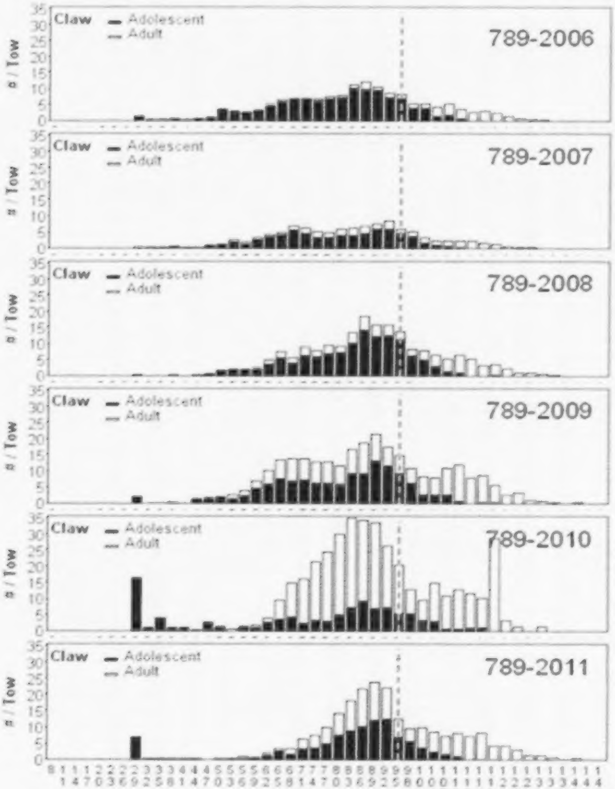


Figure 181: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from the DFO trawl survey in Conception Bay from 2006 to 2011. The vertical dashed line indicates the minimum legal size.

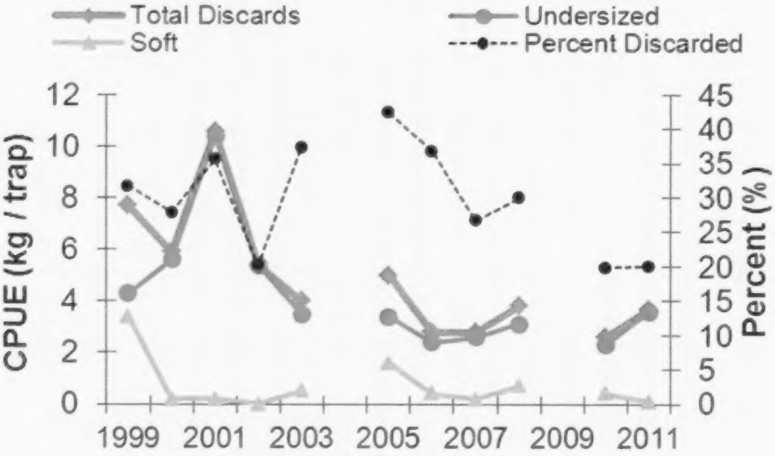


Figure 182: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from the DFO trawl survey in Conception Bay from 2006 to 2011.

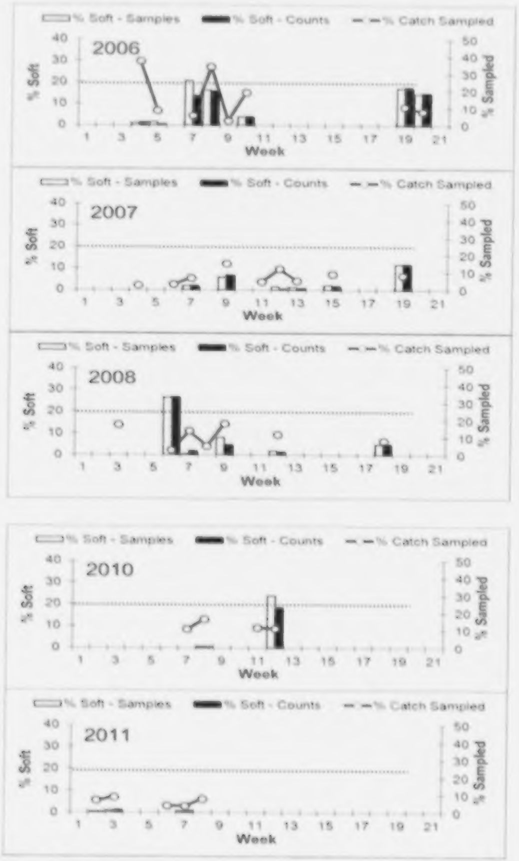


Figure 183: Trends in weekly percentages of soft-shell crab monitored and sampled in Crab Management Area (CMA) 6B from 2006 to 2011.

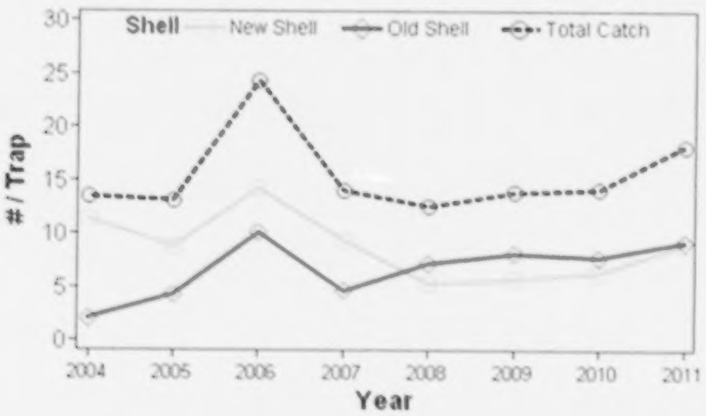


Figure 184: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 6C.

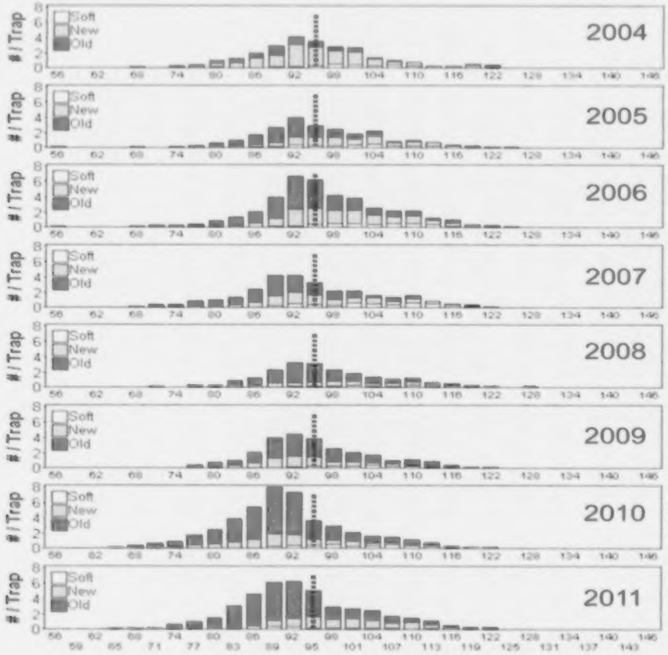


Figure 185: Trends in male carapace width distributions from core stations in Crab Management Area (CMA) 6C from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

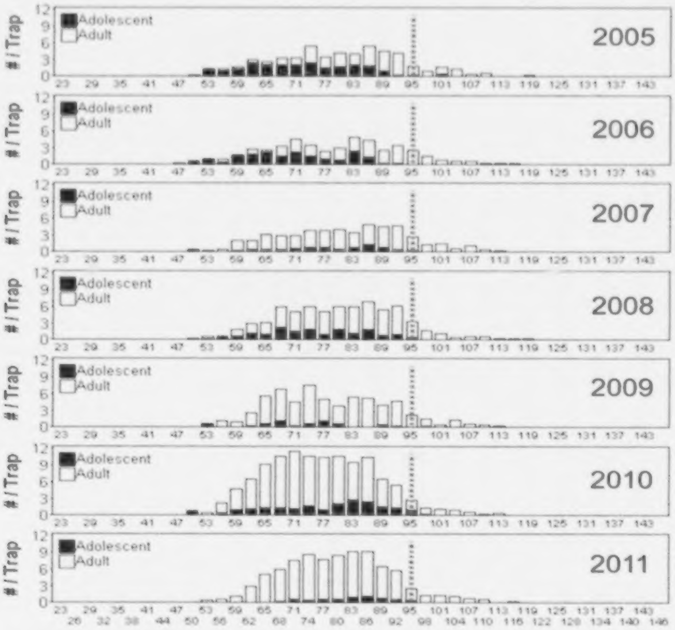


Figure 186: Trends in male carapace width distributions from small-mesh traps in Crab Management Area (CMA) 6C from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

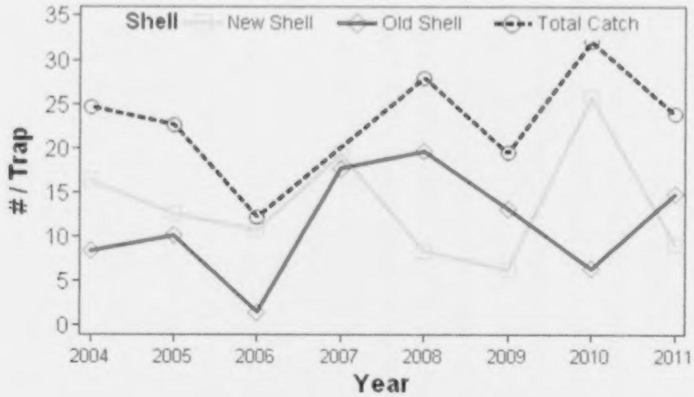


Figure 187: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 8A.

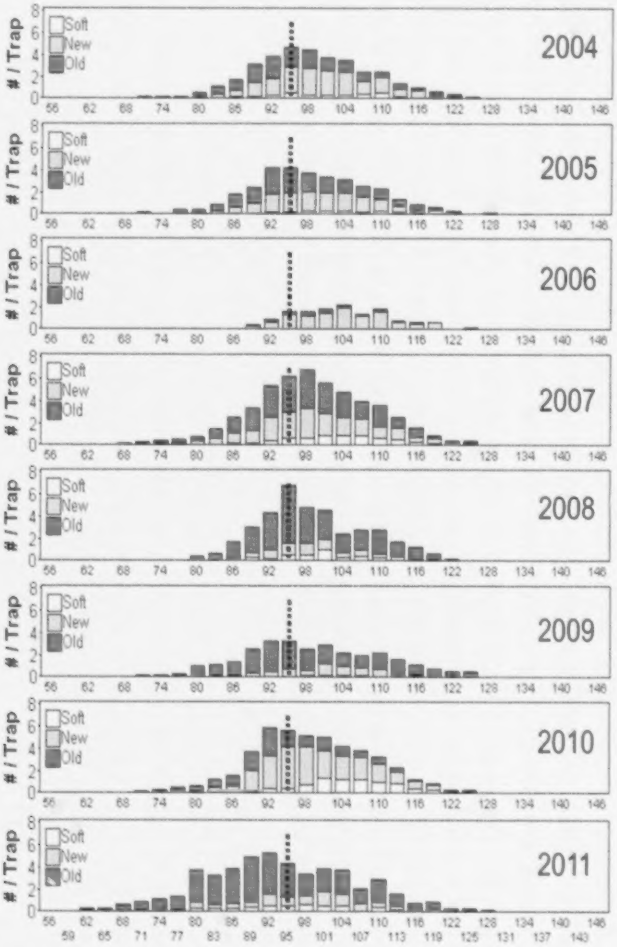


Figure 188: Trends in male carapace width distributions from core stations in Crab Management Area (CMA) 8A from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

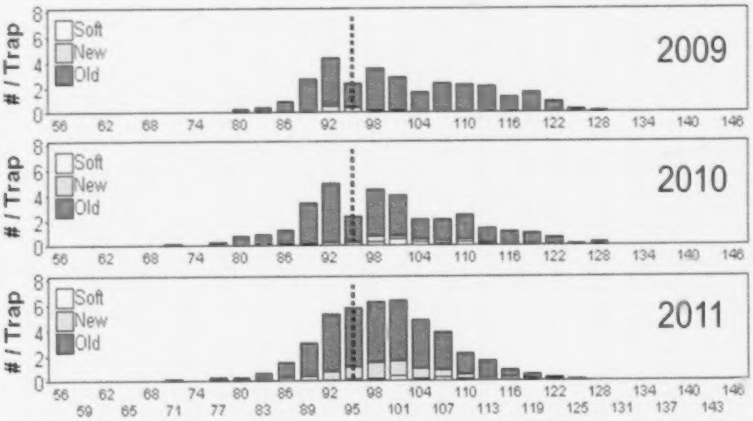


Figure 189: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Crab Management Area (CMA) 9A. The vertical dashed line indicates the minimum legal size.

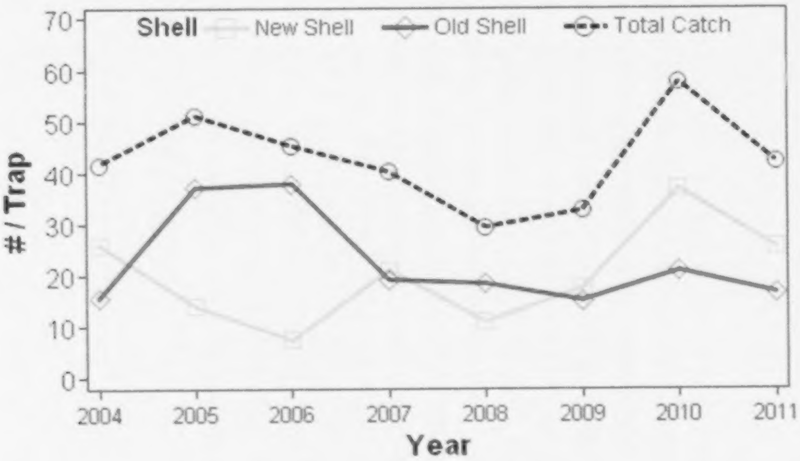


Figure 190: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 9A.

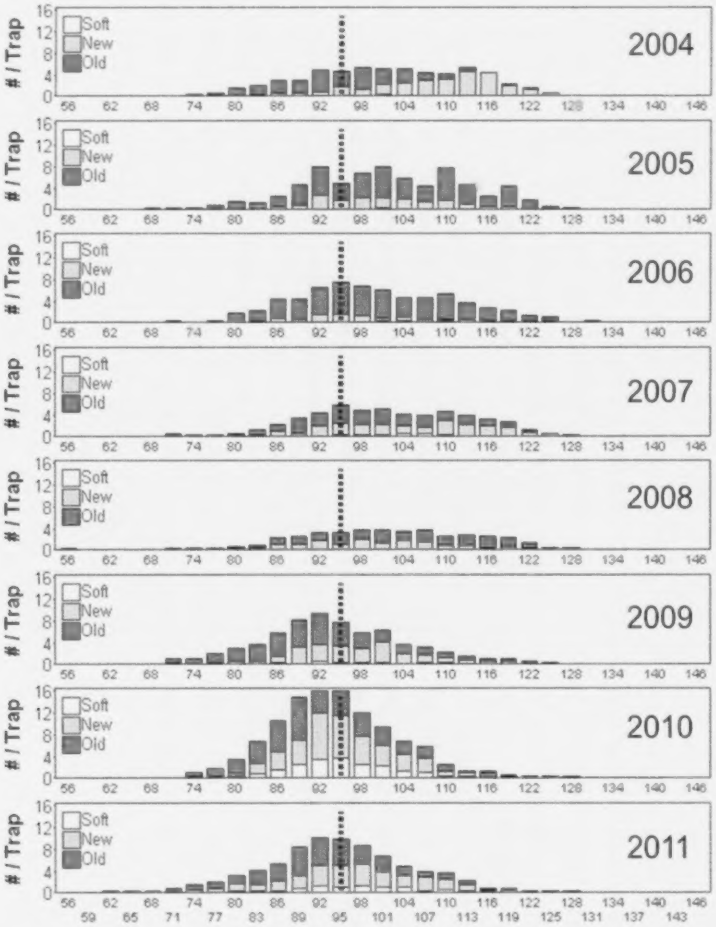


Figure 191: Trends in male carapace width distributions from core stations in Crab Management Area (CMA) 9A from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

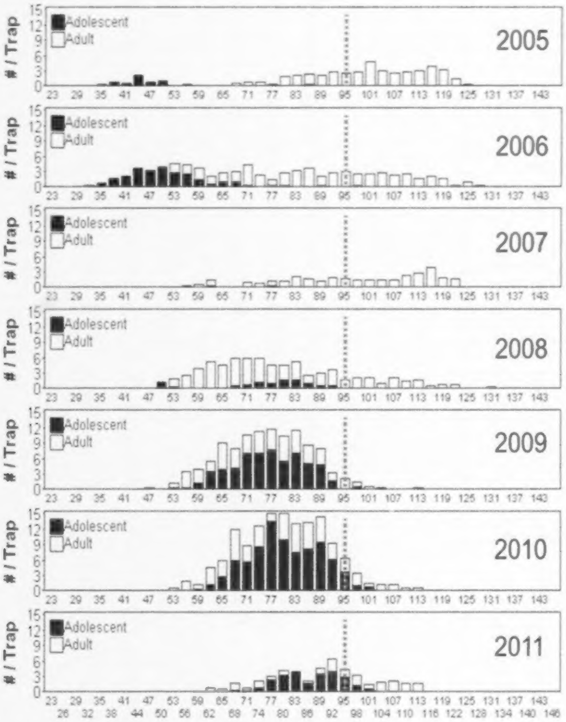


Figure 192: Trends in male carapace width distributions from small-mesh traps in Crab Management Area (CMA) 9A from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size

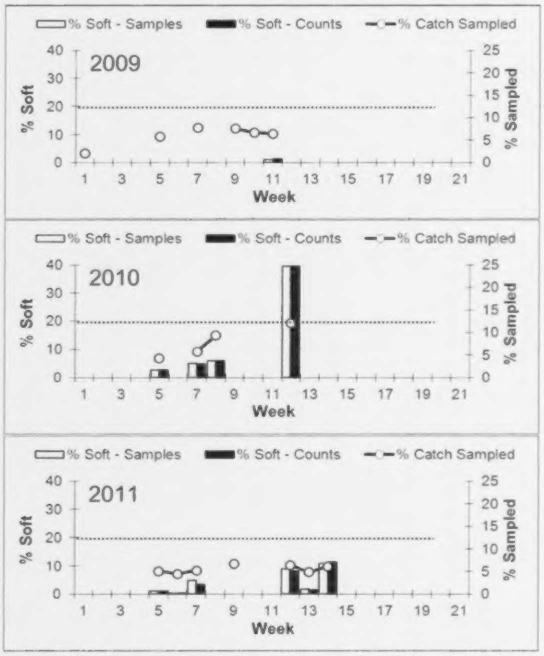


Figure 193: Trends in weekly percentages of soft-shell crab monitored and sampled in Crab Management Area (CMA) 9A from 2009 to 2011.

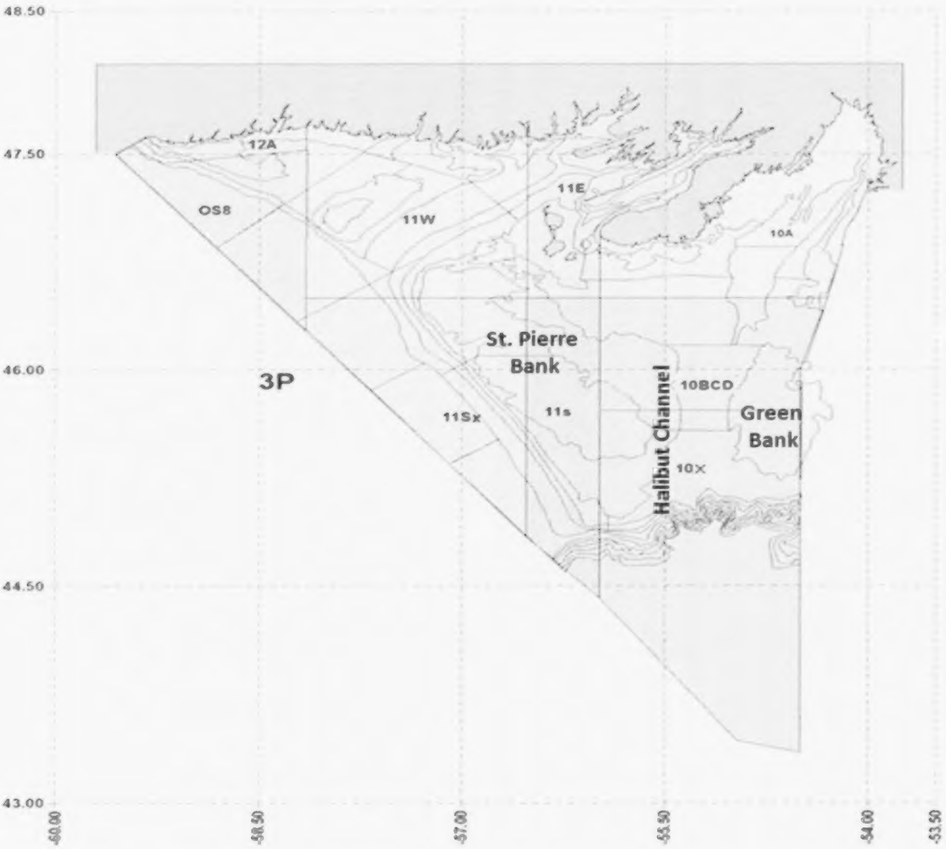

48.50
47.50
46.00
44.50
43.00
-60.00
-58.50
-57.00
-55.50
-54.00
-53.50
12A
OS8
11W
11E
10A
St. Pierre Bank
3P
11Sx
11s
10BCD
Halibut Channel
Green Bank
10X

Figure 194: Map of Subdiv. 3Ps showing Crab Management Area (CMA) and important bathymetric features.

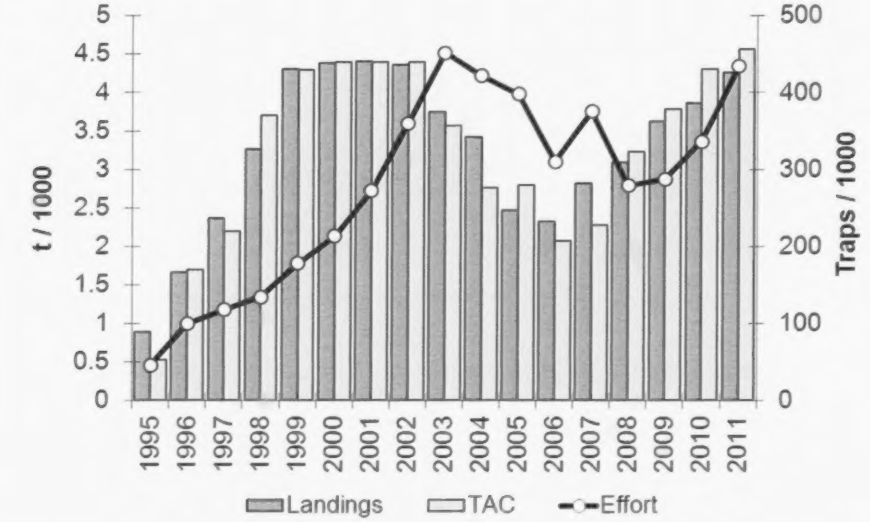


Figure 195: Trends in Subdiv. 3Ps offshore landings, total allowable catch (TAC), and fishing effort.

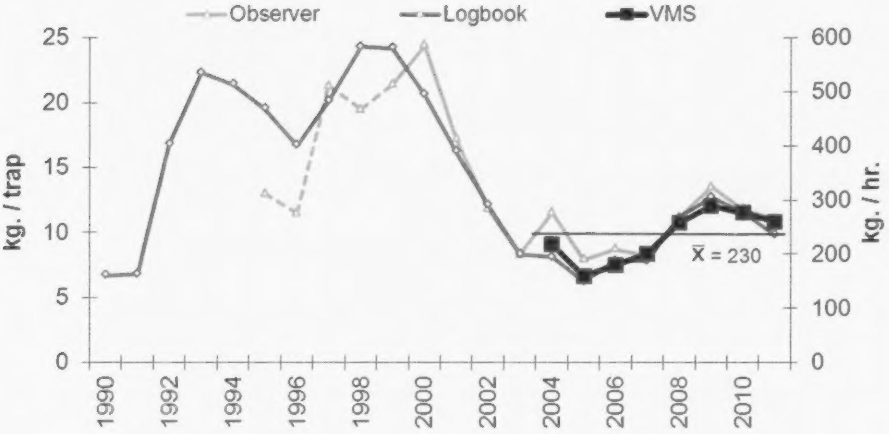


Figure 196: Trends in commercial logbook-based, observer-based, and VMS-based catch per unit effort (CPUE) in the Subdiv. 3Ps offshore fishery. Solid black line denotes long-term VMS average.

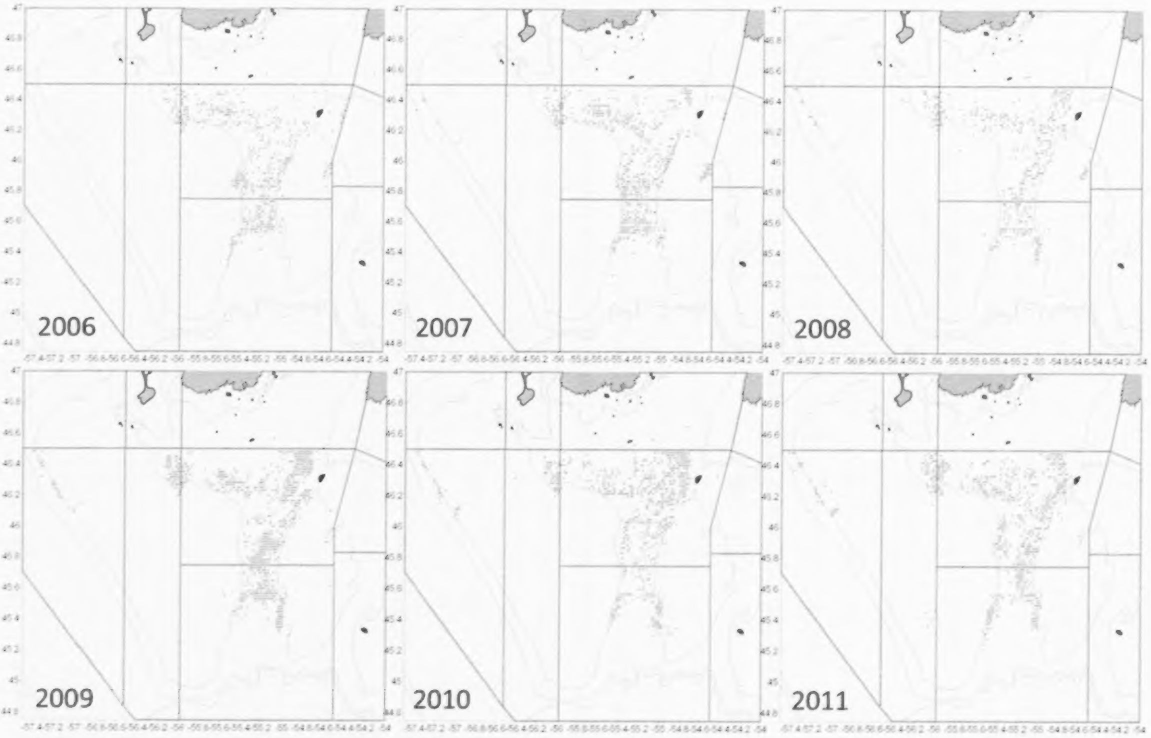

2006
2007
2008
2009
2010
2011

Figure 197: Spatial distribution of Subdiv. 3Ps fishing effort by year.

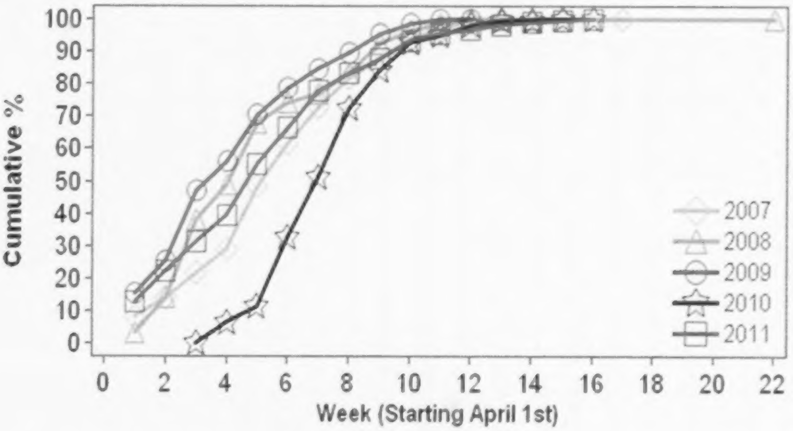


Figure 198: Seasonal trends in fishing effort for Subdiv. 3Ps offshore during 2007-2011.

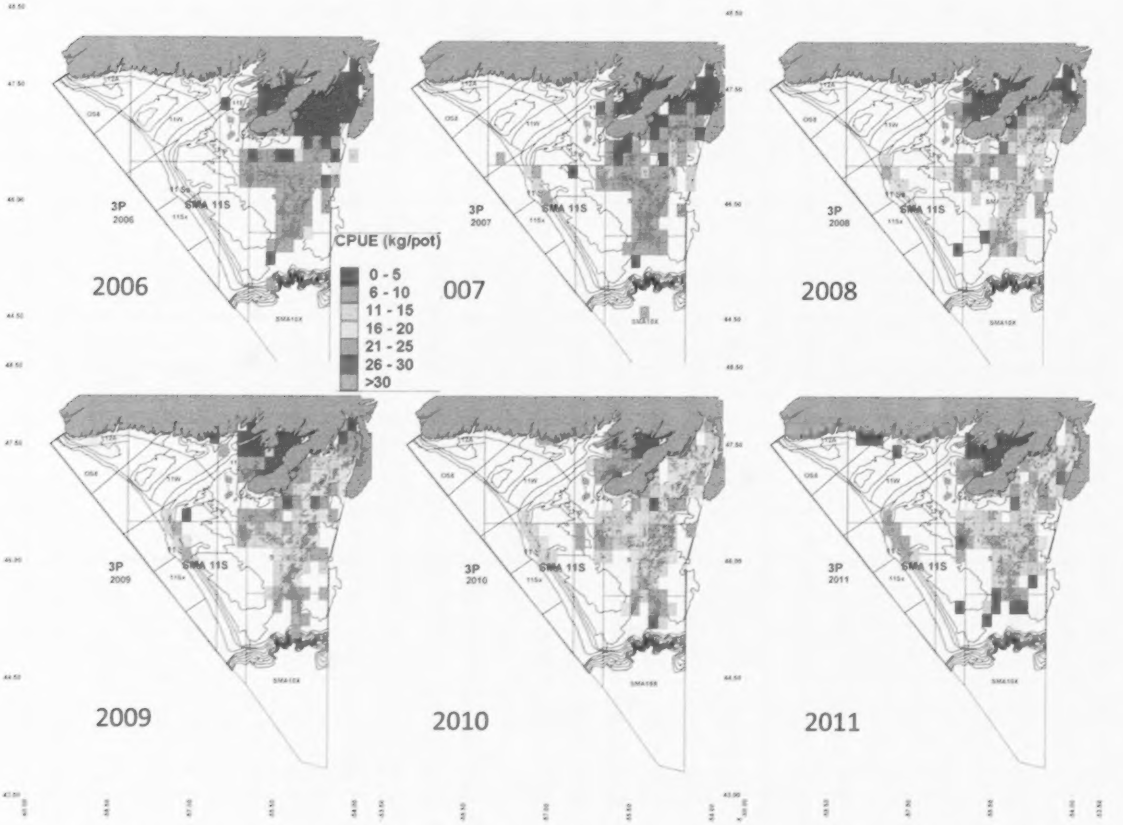

3P
2006
SMA 11S
CPUE (kg/pot)
0 - 5
6 - 10
11 - 15
16 - 20
21 - 25
26 - 30
>30
2006
3P
2007
SMA 11S
007
3P
2008
SMA 11S
2008
3P
2009
SMA 11S
2009
3P
2010
SMA 11S
2010
3P
2011
SMA 11S
2011

Figure 199: Spatial distribution of Subdiv. 3Ps logbook catch per unit effort (CPUE) by year.

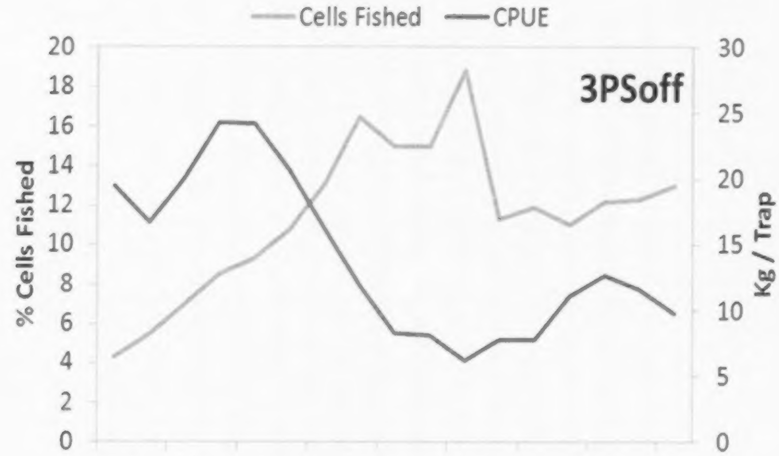


Figure 200: Trends in Subdiv. 3Ps offshore commercial catch per unit effort (CPUE) vs. the percentage of 5' x 5' cells fished.

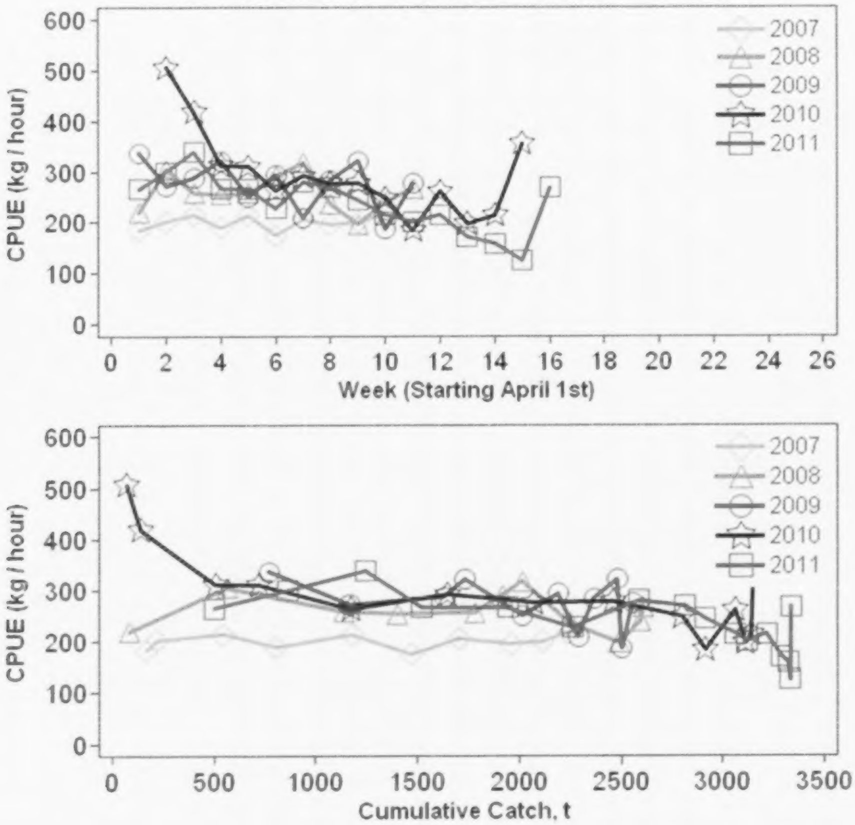


Figure 201: Seasonal trends in VMS-based catch per unit effort (CPUE) for Subdiv. 3Ps offshore during 2006-2010; by week (above), and in relation to cumulative catch (below).

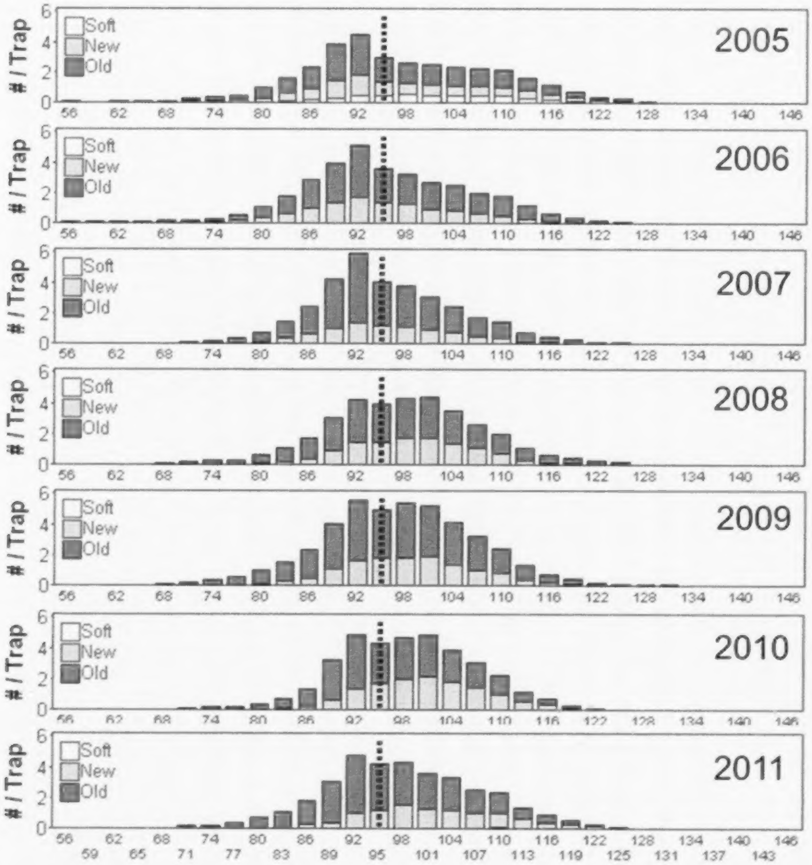


Figure 202: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Subdiv. 3Ps offshore. The vertical dashed line indicates the minimum legal size.

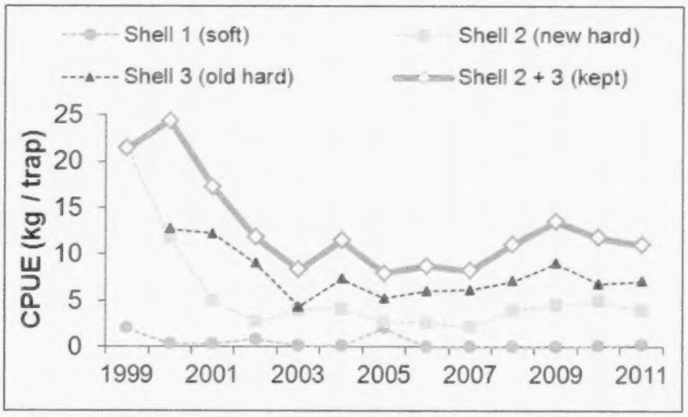


Figure 203: Trends in Subdiv. 3Ps offshore observer catch rates of exploitable crabs by shell condition from at-sea sampling.

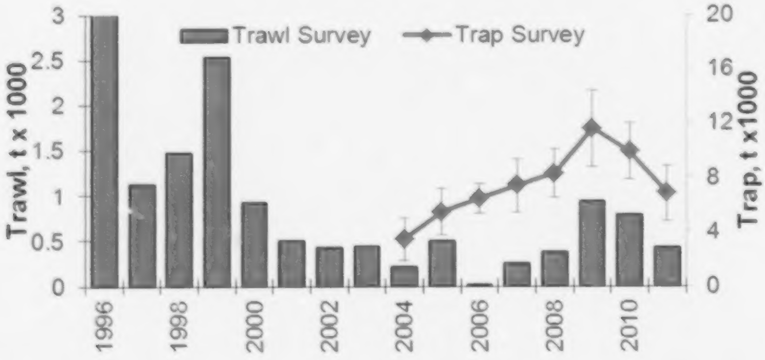
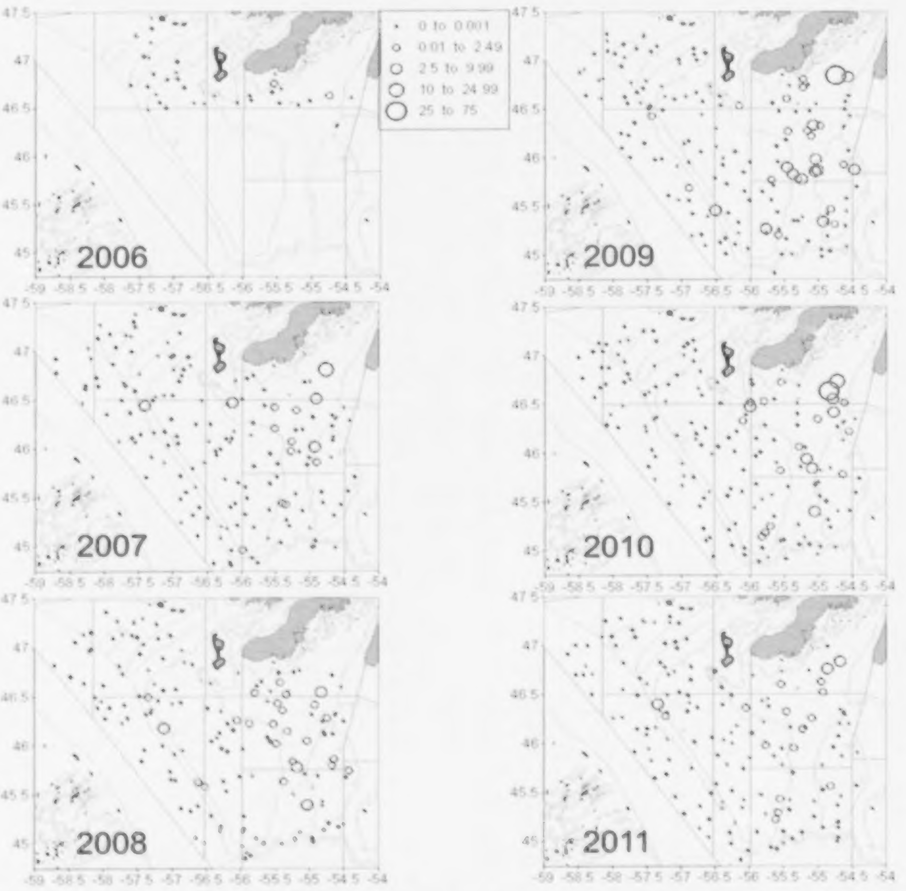


Figure 204: Trends in the Subdiv. 3Ps offshore spring trawl survey exploitable biomass index and the Collaborative Post-Season (CPS) trap survey biomass index. The trawl survey was incomplete in 2006.



0 to 0.001
0.01 to 2.49
2.5 to 9.99
10 to 24.99
25 to 75
2006
2009
2007
2010
2008
2011
47.5
47
46.5
46
45.5
45
-59
-58.5
-58
-57.5
-57
-56.5
-56
-55.5
-55
-54.5
-54

Figure 205: Spatial distribution of catches (number/set) of exploitable crab in the Subdiv. 3Ps offshore trawl survey.

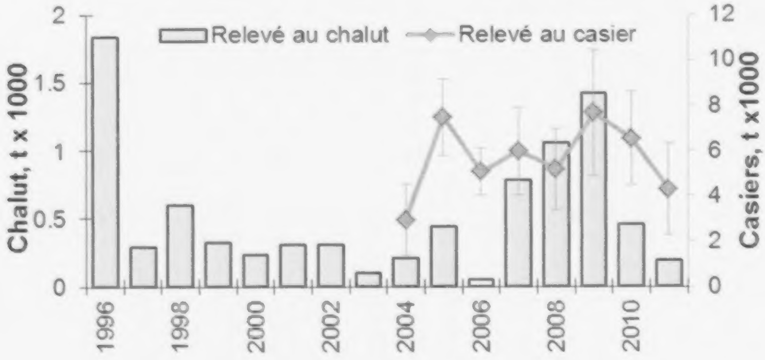


Figure 206: Trends in the Subdiv. 3Ps offshore spring trawl survey pre-recruit biomass index and the Collaborative Post-Season (CPS) trap survey biomass index. The trawl survey was incomplete in 2006.

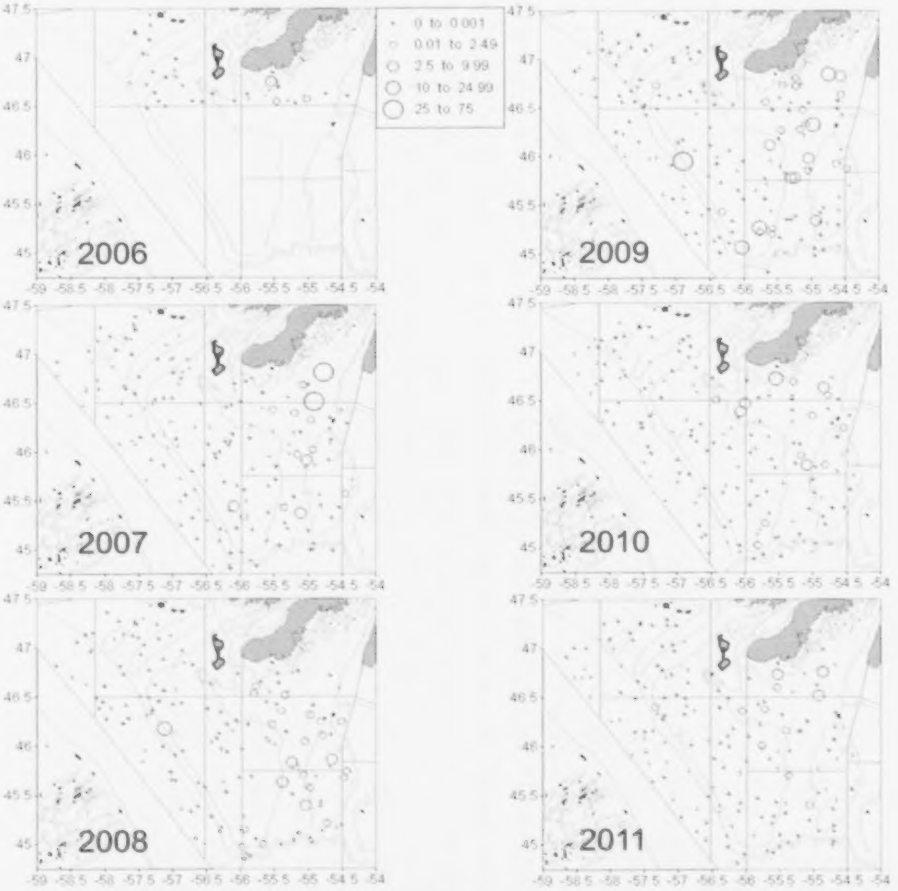

0 to 0.001
0.01 to 2.49
2.5 to 9.99
10 to 24.99
25 to 75
2006
2009
2007
2010
2008
2011
47.5
47
46.5
46
45.5
45
-59
-58.5
-58
-57.5
-57
-56.5
-56
-55.5
-55
-54.5
-54

Figure 207: Spatial distribution of catches (number/set) of exploitable crab in the Subdiv. 3Ps offshore trawl survey.

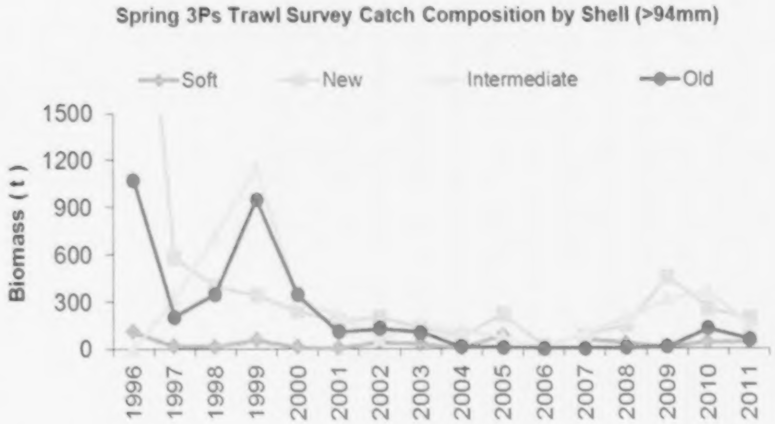


Figure 208: Trends, by shell condition, in legal-sized males for Subdiv. 3Ps offshore from spring trawl surveys.

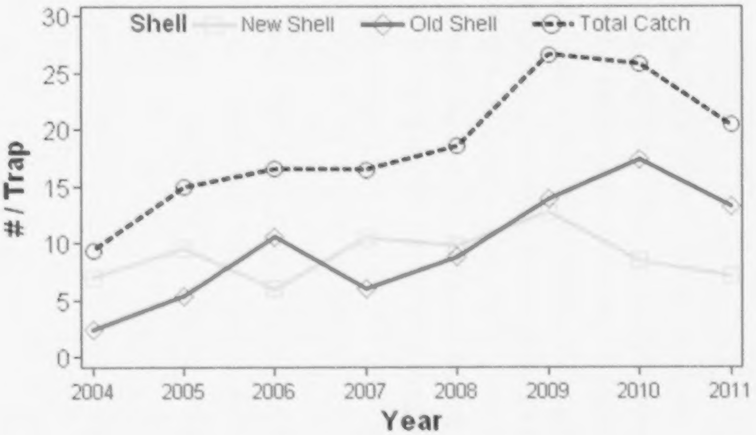


Figure 209: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Subdiv. 3Ps offshore Collaborative Post-Season (CPS) trap survey.

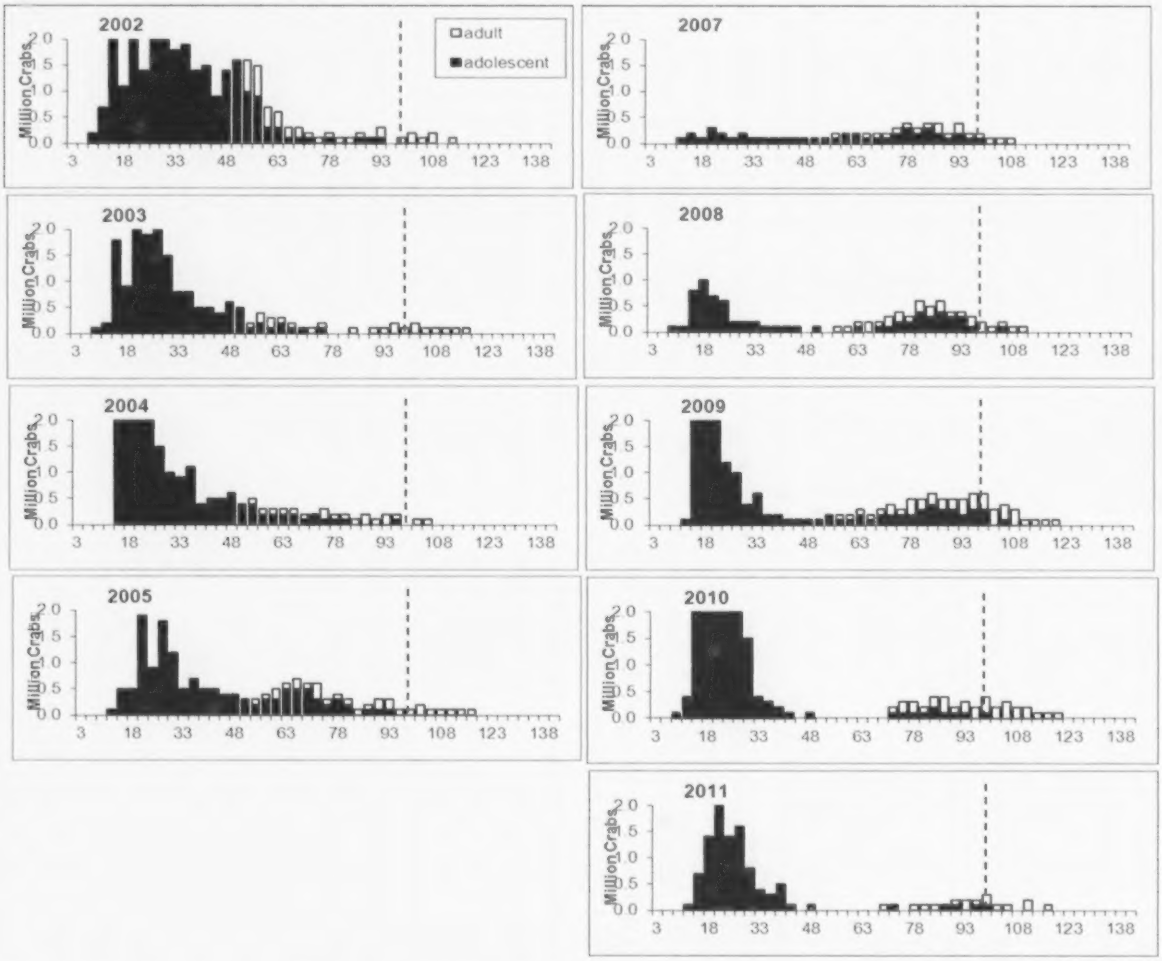


Figure 210: Abundance indices by carapace width for Subdiv. 3Ps juveniles plus adolescents (dark bars) versus adults (open bars) from spring trawl surveys.

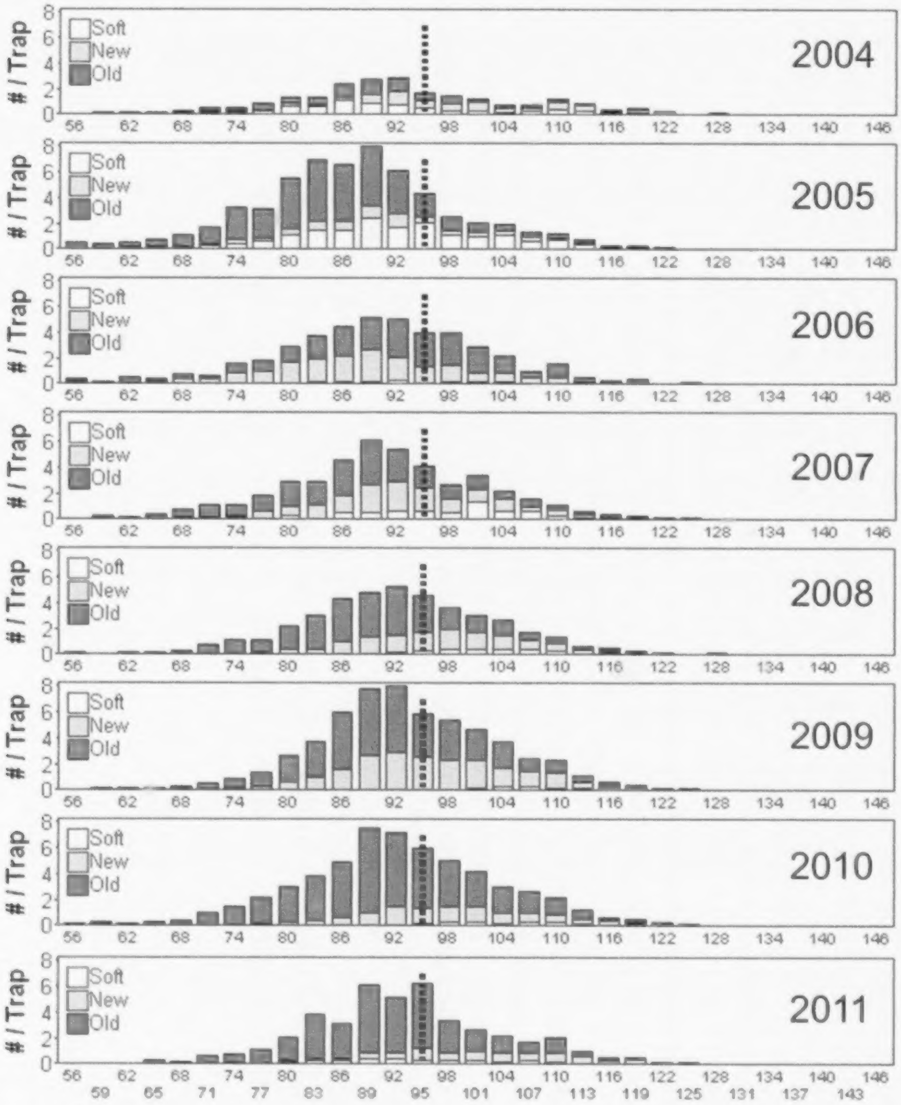


Figure 211: Trends in male carapace width distributions from core stations in the Subdiv. 3Ps offshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

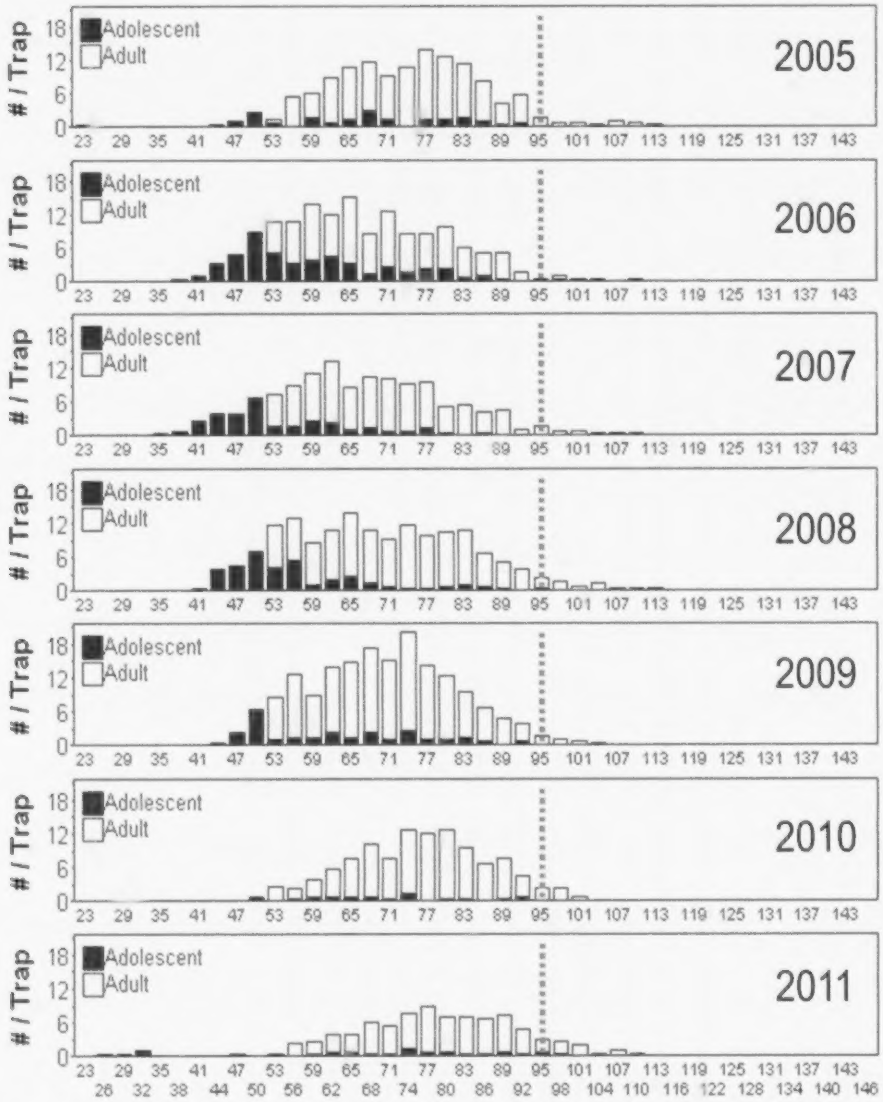


Figure 212: Trends in male carapace width distributions from small-mesh traps in the Subdiv. 3Ps offshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

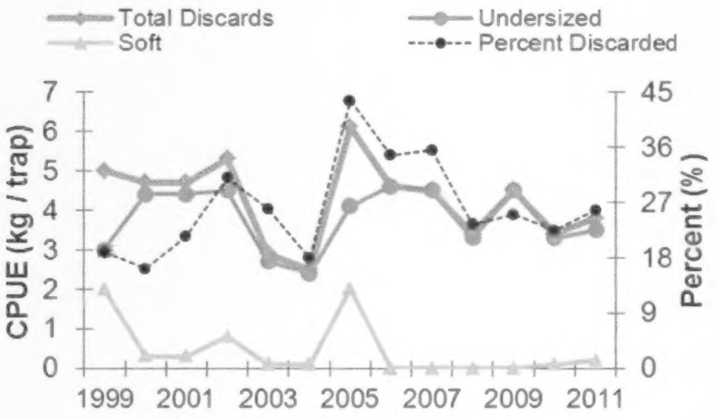


Figure 213: Trends in Subdiv. 3Ps offshore observer catch rates of total discards, under-sized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

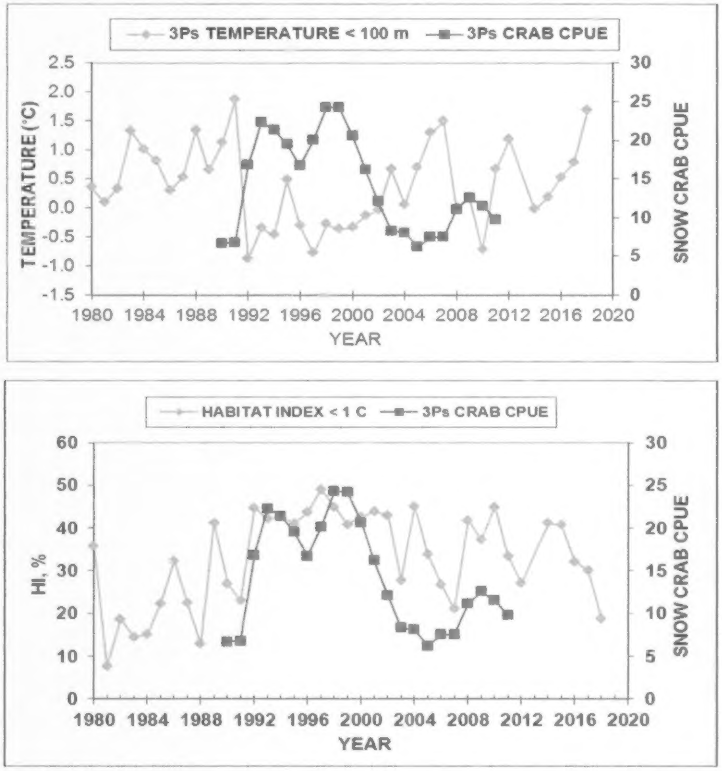


Figure 214: Trends in the Subdiv. 3Ps offshore catch per unit effort (CPUE) vs. bottom temperature at a seven year lag (above) and vs. the spatial extent of <1 degree water (below).

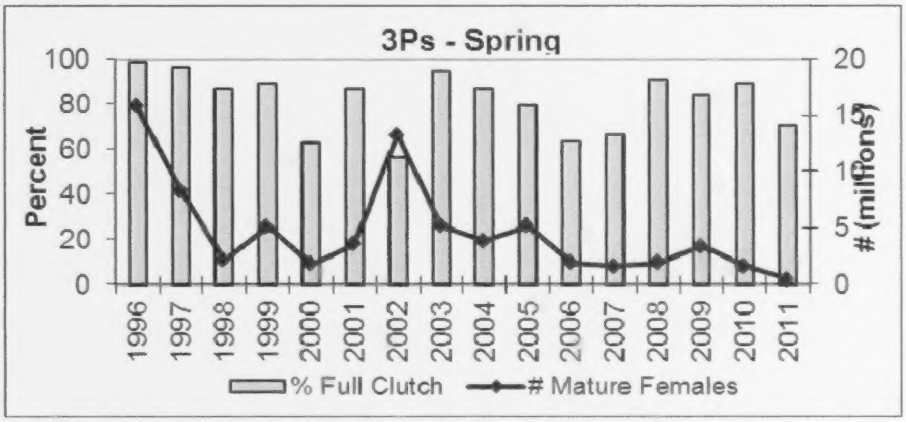


Figure 215: Trends in mature female abundance and percentage bearing full clutches of viable eggs in Subdiv. 3Ps from spring multi-species surveys.

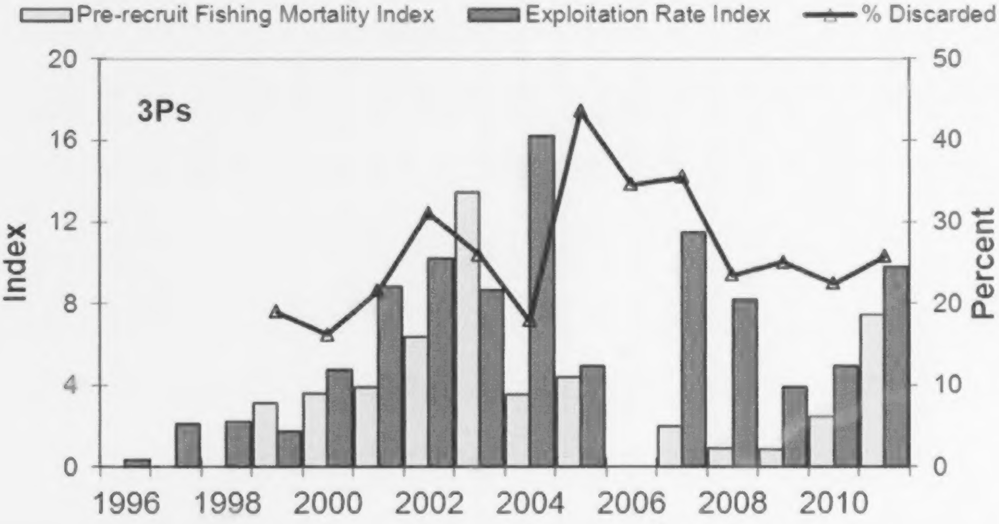


Figure 216: Trends in Subdiv. 3Ps offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery. (No 2006 exploitation rate or pre-recruit fishing mortality indices because of an incomplete 2006 survey).

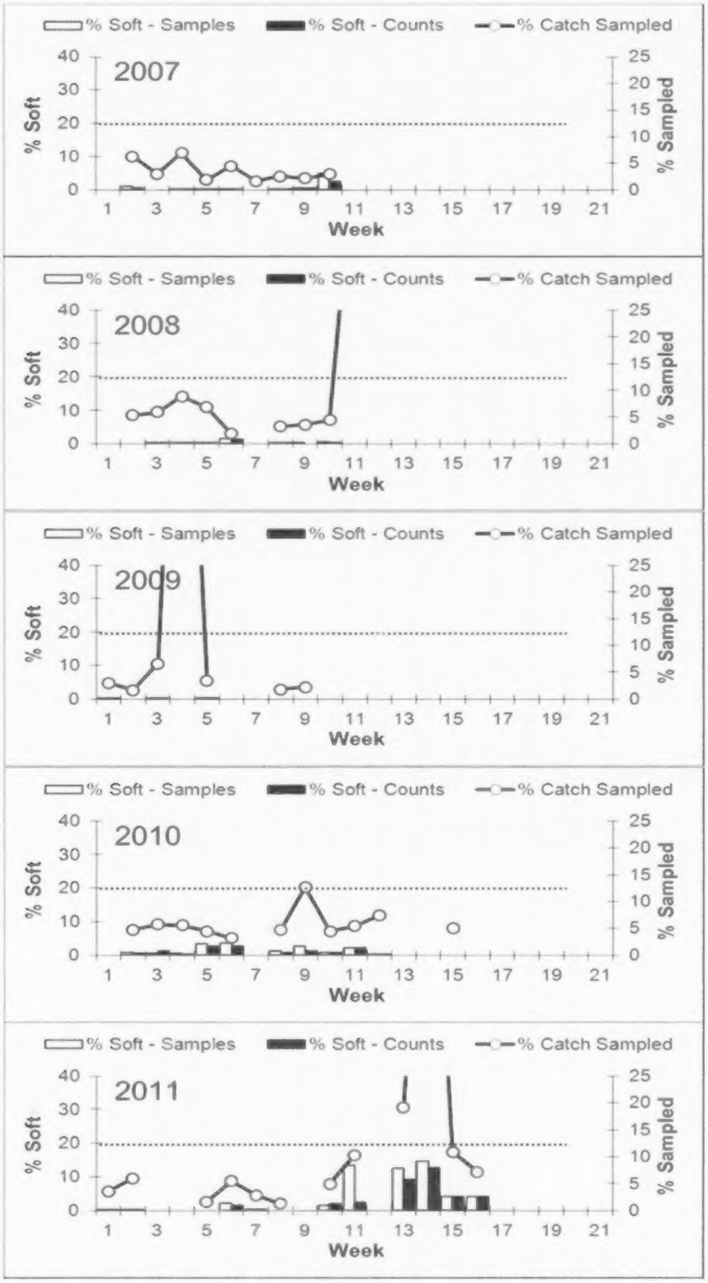


Figure 217: Trends in weekly percentages of soft-shell crab monitored and sampled in Subdiv. 3Ps Offshore from 2006 to 2010.

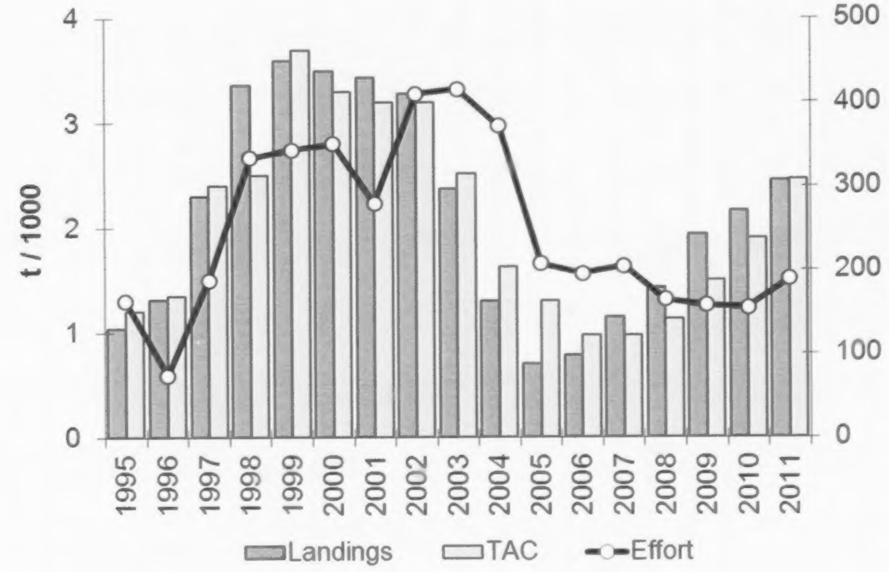


Figure 218: Trends in Subdiv. 3Ps inshore landings, total allowable catch (TAC), and fishing effort.

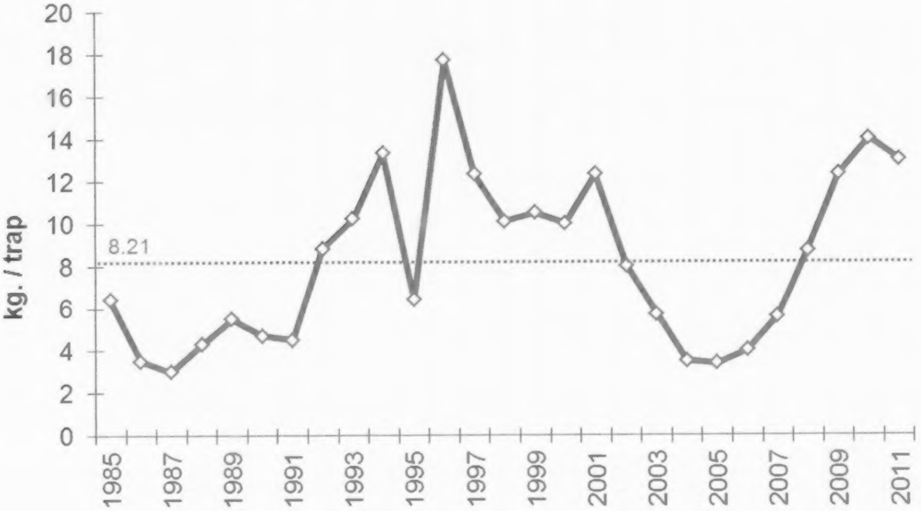


Figure 219: Trends in commercial logbook-based catch per unit effort (CPUE) in the Subdiv. 3Ps inshore fishery.

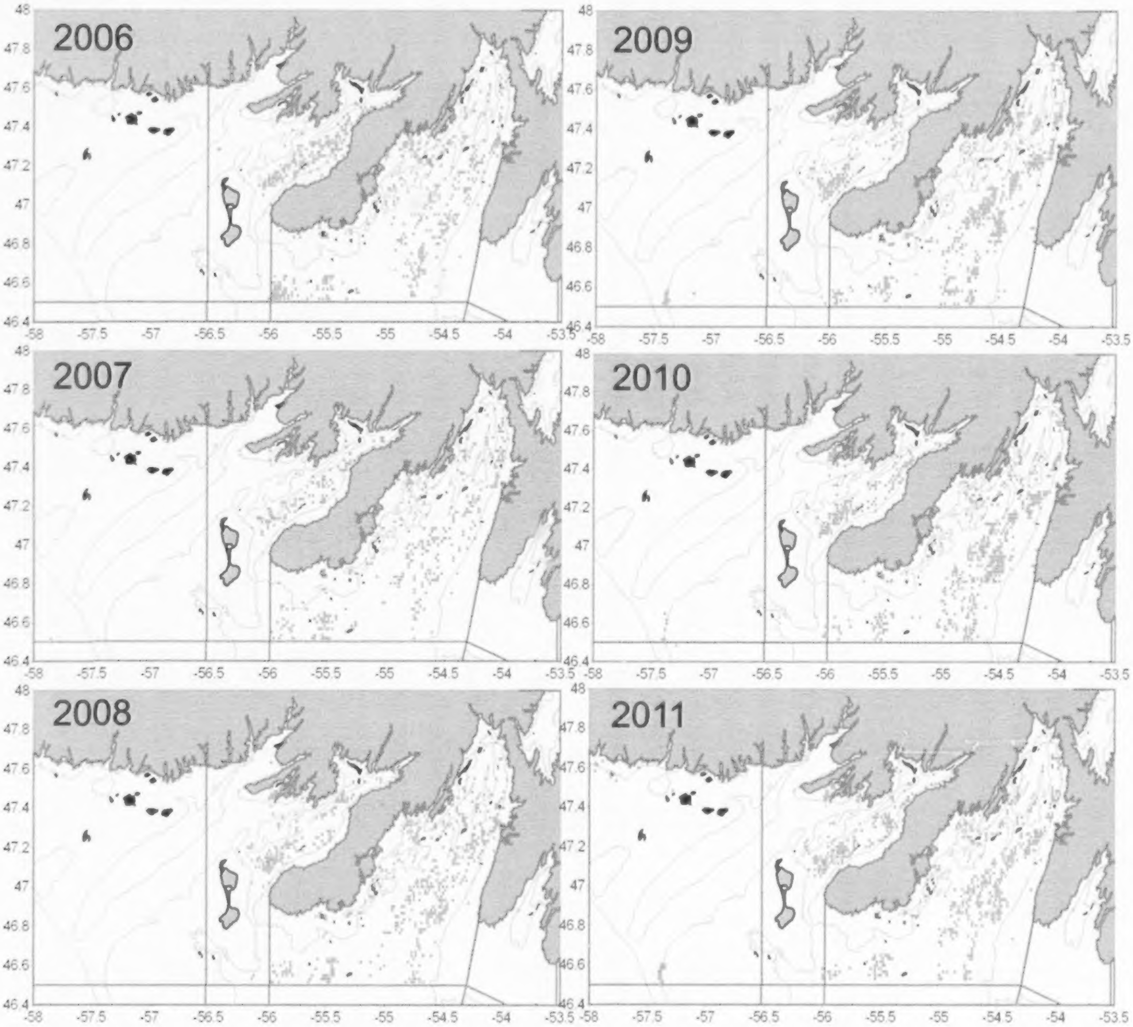

2006
2009
2007
2010
2008
2011
48
47.8
47.6
47.4
47.2
47
46.8
46.6
46.4
-58
-57.5
-57
-56.5
-56
-55.5
-55
-54.5
-54
-53.5

Figure 220: Spatial distribution of Subdiv. 3Ps inshore fishing effort by year.

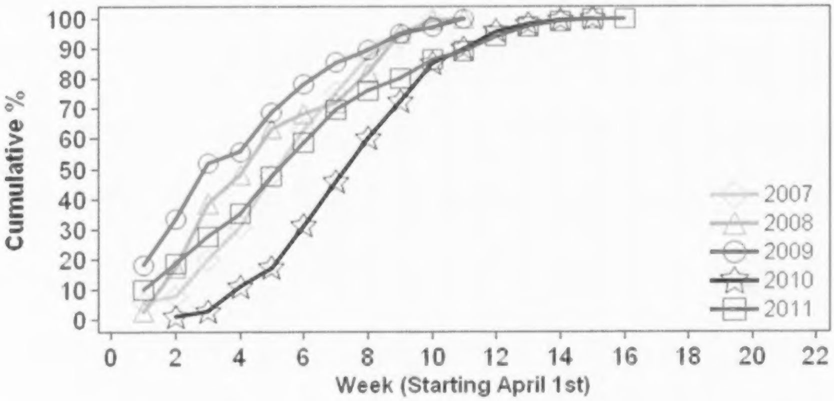


Figure 221: Seasonal trends in weekly fishing effort for Subdiv. 3Ps inshore during 2007-2011.

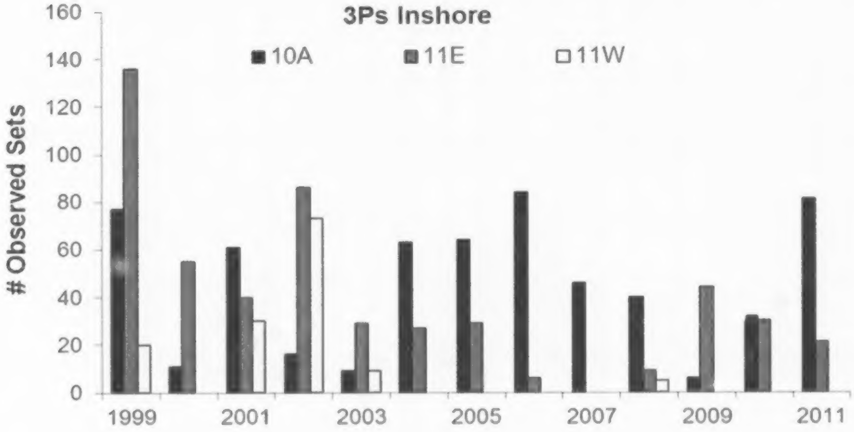


Figure 222: Trends in number of observed sets by Crab Management Area (CMA) and year in Subdiv. 3Ps inshore.

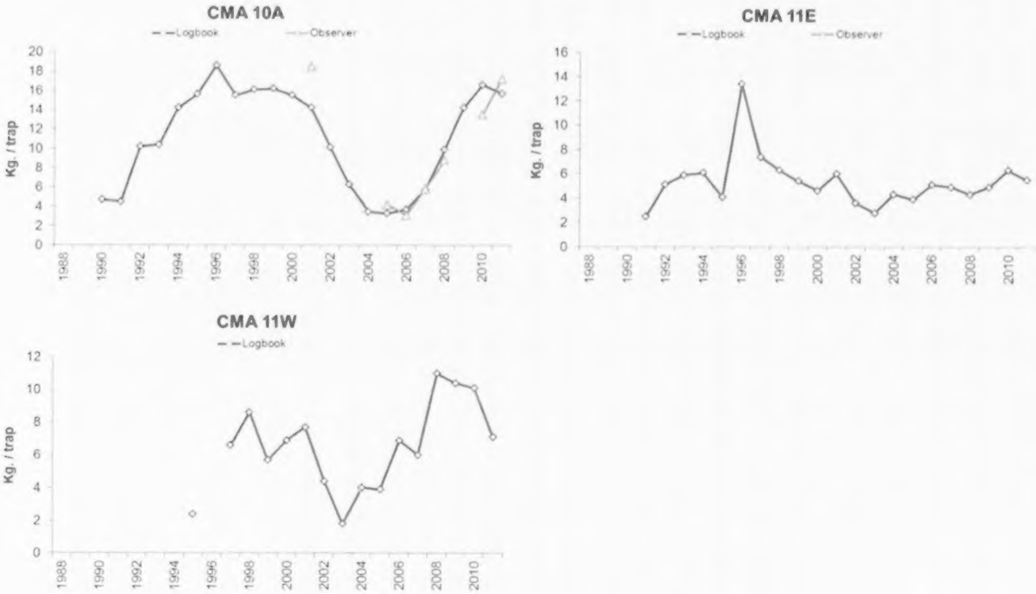


Figure 223: Trends in Subdiv. 3Ps inshore logbook catch per unit effort (CPUE) and CPUE by Crab Management Area (CMA).

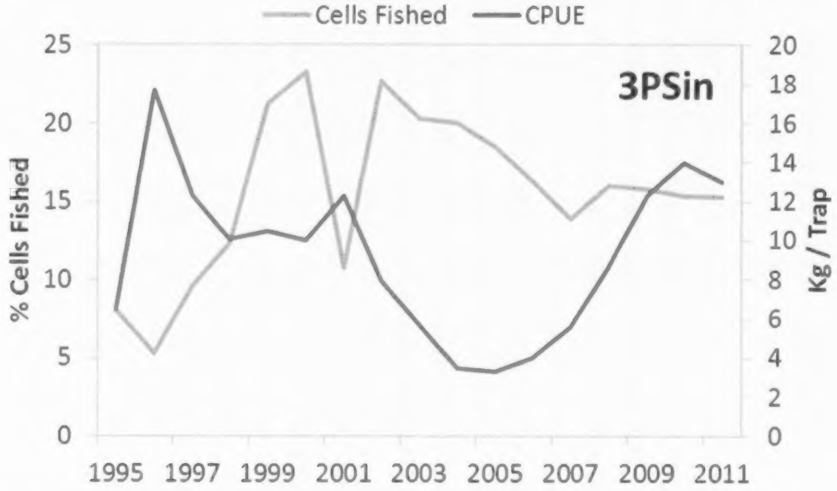


Figure 224: Trends in Subdiv. 3Ps inshore logbook catch per unit effort (CPUE) vs. the percentage of 5' x 5' cells fished.

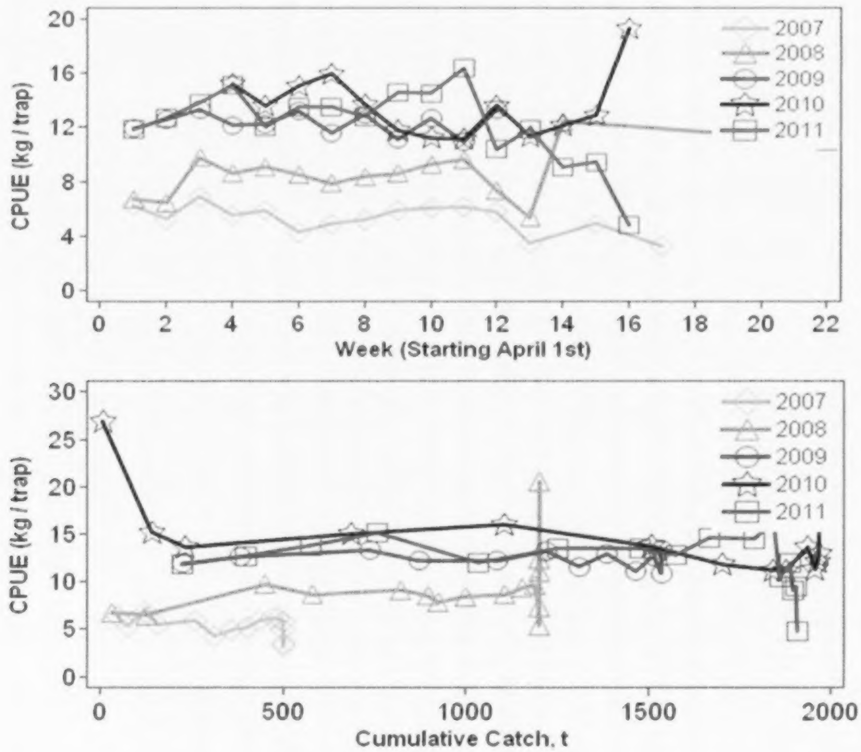


Figure 225: Seasonal trends in logbook-based catch per unit effort (CPUE) for Subdiv. 3Ps inshore during 2007-2011; by week (above), and in relation to cumulative catch (below).

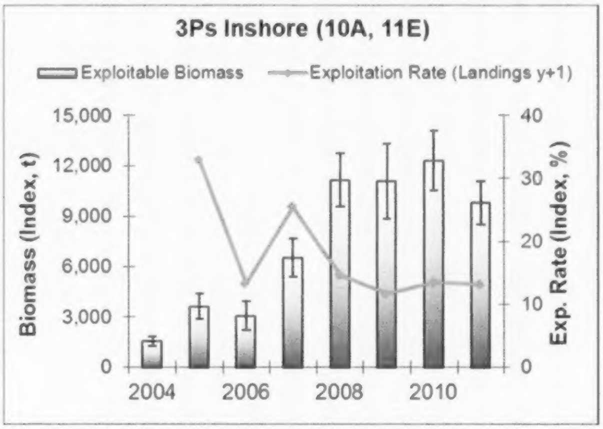


Figure 226: Exploitable biomass and exploitation rate indices from the Collaborative Post-Season (CPS) trap survey in Subdiv. 3Ps inshore.

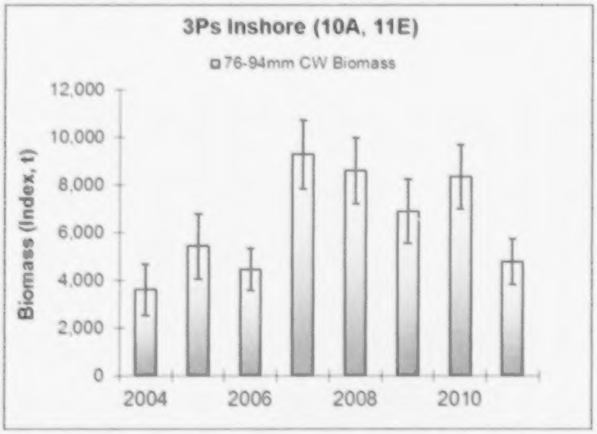


Figure 227: Pre-recruit biomass index based on the Collaborative Post-Season (CPS) trap survey in Subdiv. 3Ps inshore.

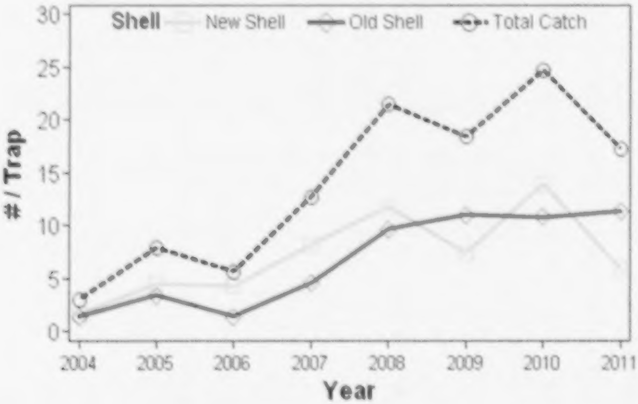


Figure 228: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Subdiv. 3Ps inshore.

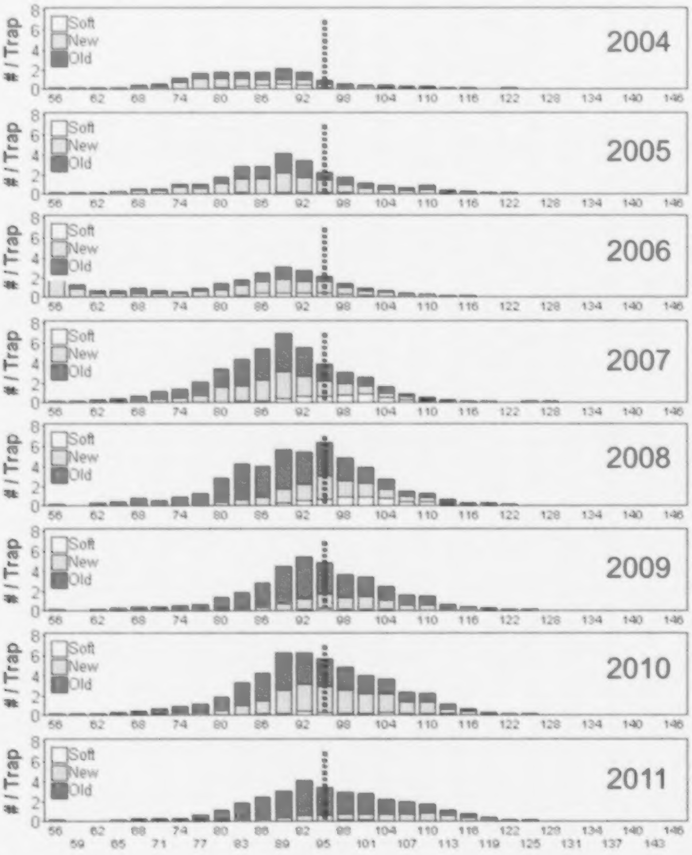


Figure 229: Trends in male carapace width distributions from core stations in the Subdiv. 3Ps inshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

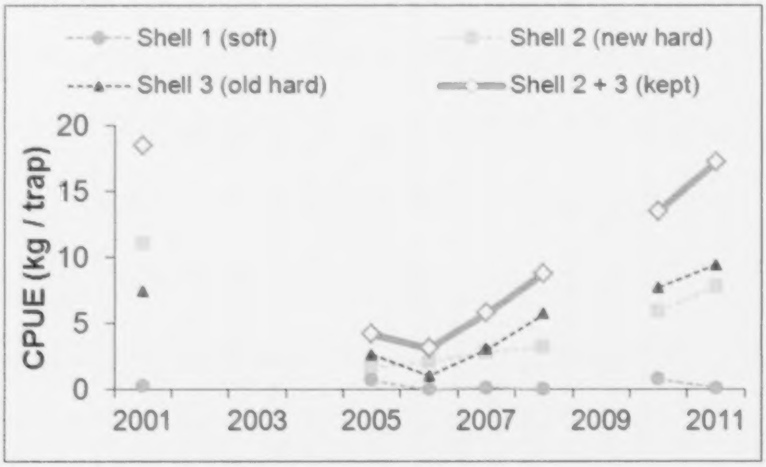


Figure 230: Trends in Crab Management Area (CMA) 10A observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

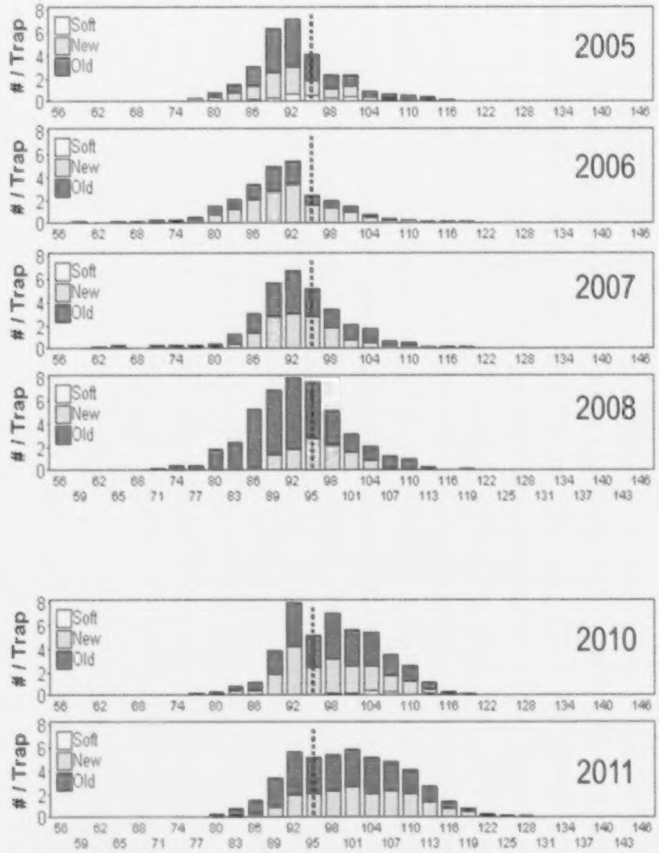


Figure 231: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Crab Management Area (CMA) 10A. The vertical dashed line indicates the minimum legal size.

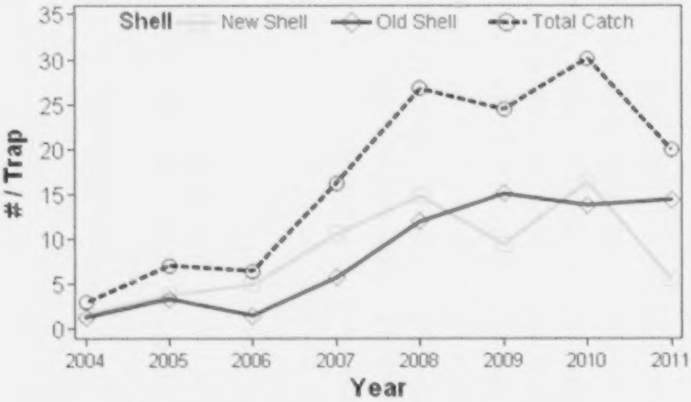


Figure 232: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 10A.

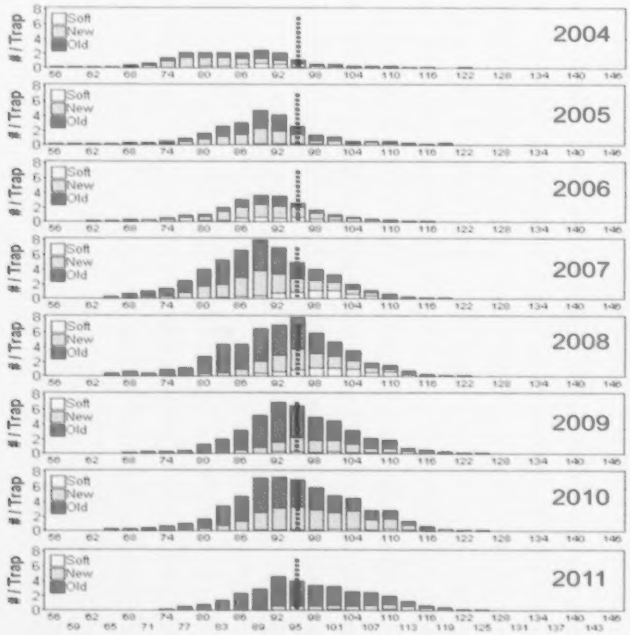


Figure 233: Trends in male carapace width distributions by shell condition from core stations in Crab Management Area (CMA) 10A from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

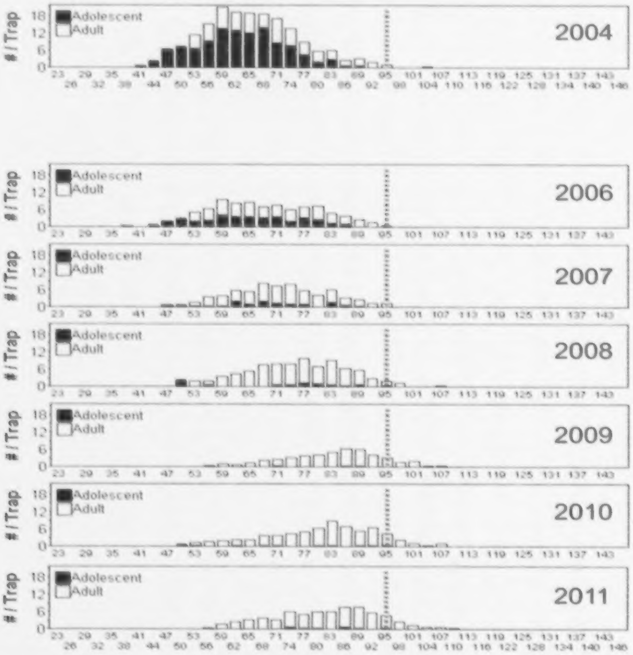


Figure 234: Trends in males carapace width distributions from small-mesh traps in Crab Management Area (CMA) 10A from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

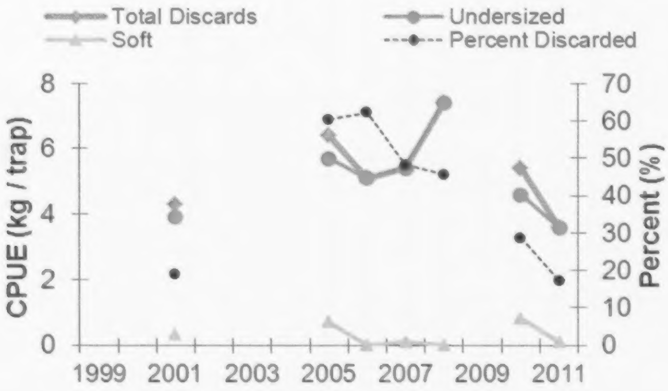


Figure 235: Trends in Crab Management Area (CMA) 10A observer catch rates of total discards, undersized discards, and legal-sized discards, as well as the percentage of the catch discarded.

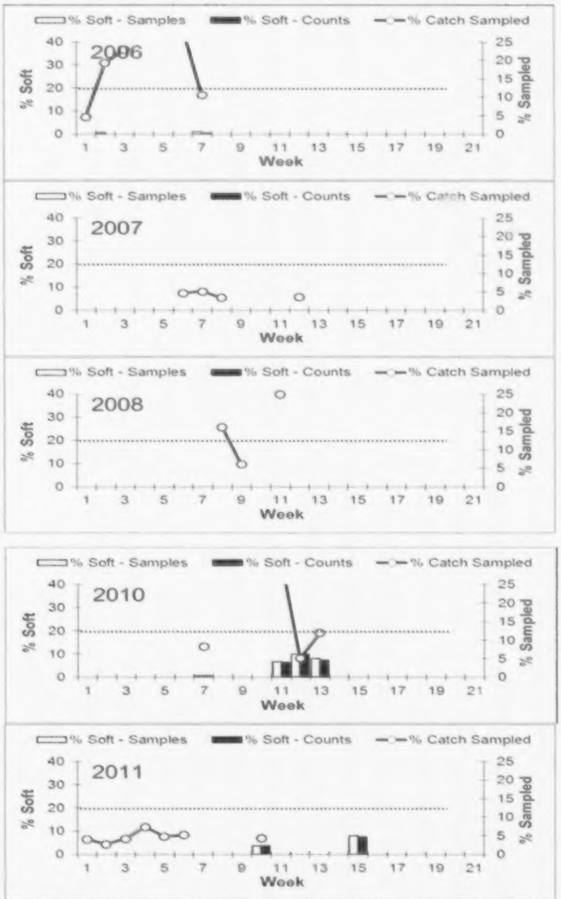


Figure 236: Trends in weekly percentages of soft-shell crab monitored and sampled in Crab Management Area (CMA) 10A from 2006 to 2011.

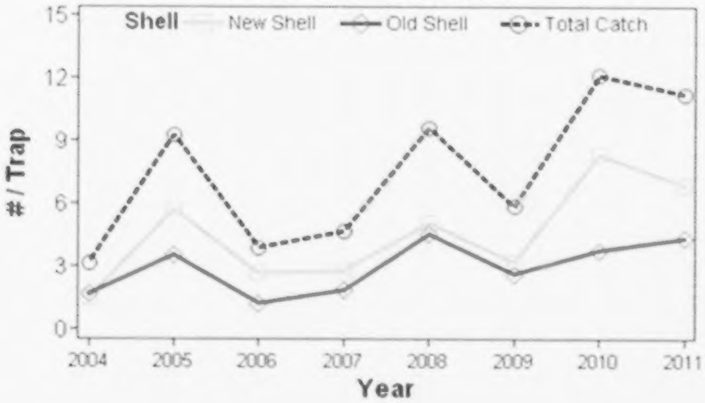


Figure 237: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 11E.

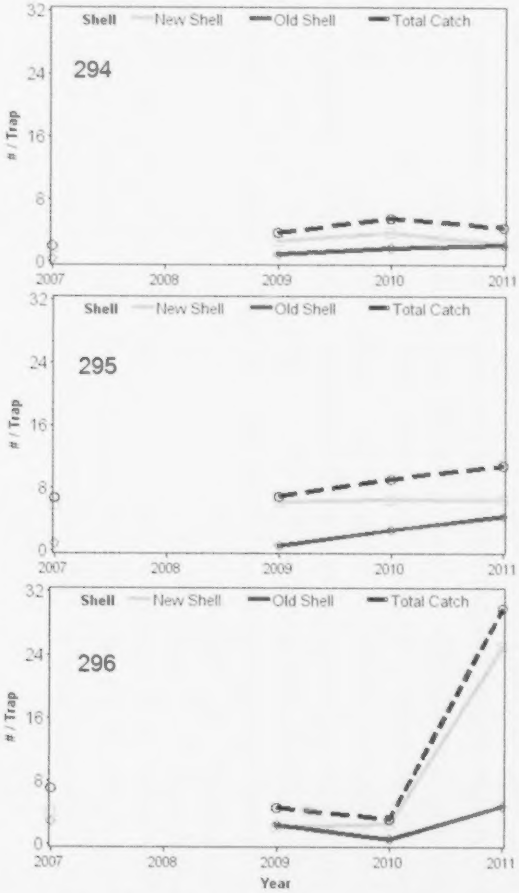


Figure 238: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from strata occupied in the DFO trap survey in Fortune Bay. No survey was conducted in 2008.

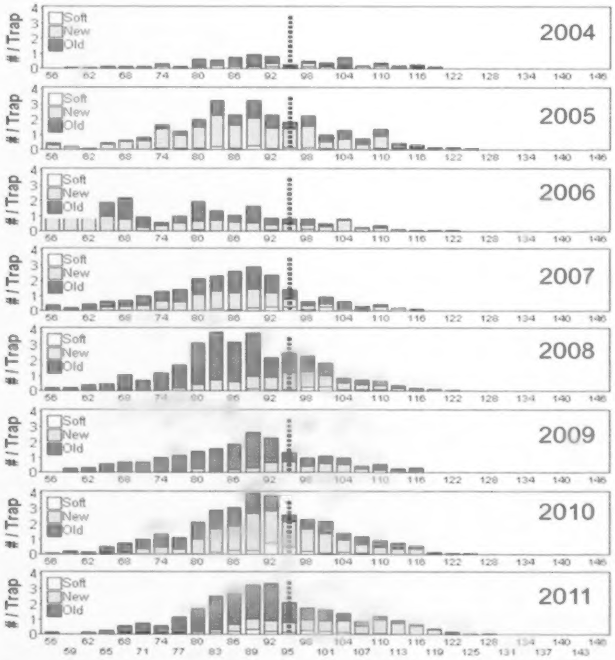


Figure 239: Trends in male carapace width distributions from core stations in Crab Management Area (CMA) 11E from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line represents the minimum legal size.

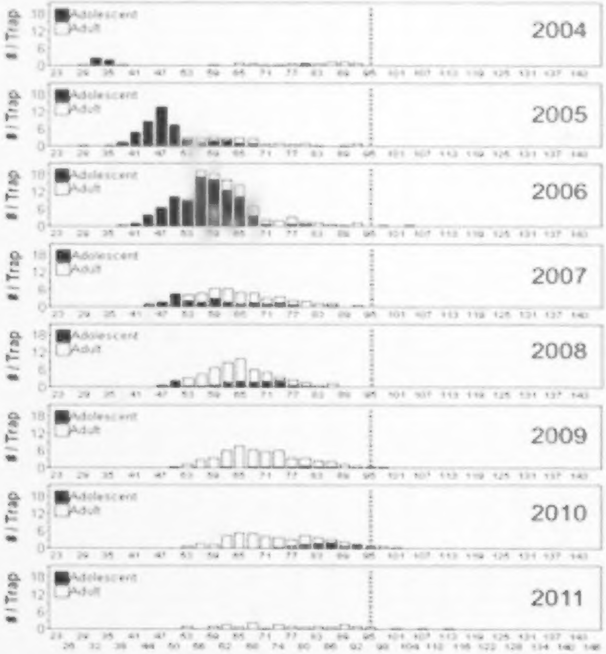


Figure 240: Trends in males carapace width distributions from small-mesh traps in Crab Management Area (CMA) 11E from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

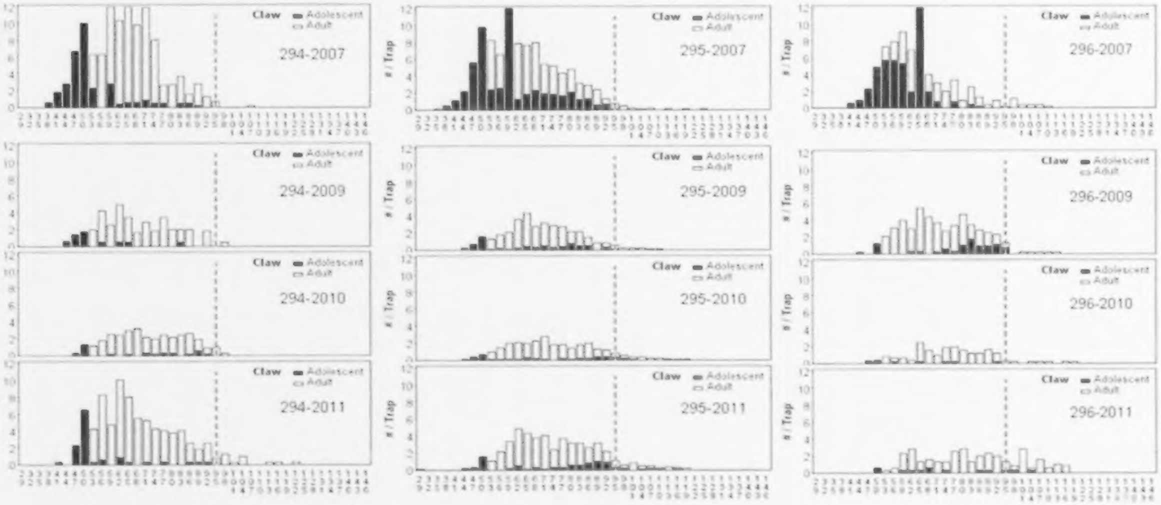


Figure 241: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in the DFO trap survey in Fortune Bay from 2007 to 2011. The vertical dashed line indicates the minimum legal size. No survey was conducted in 2008.

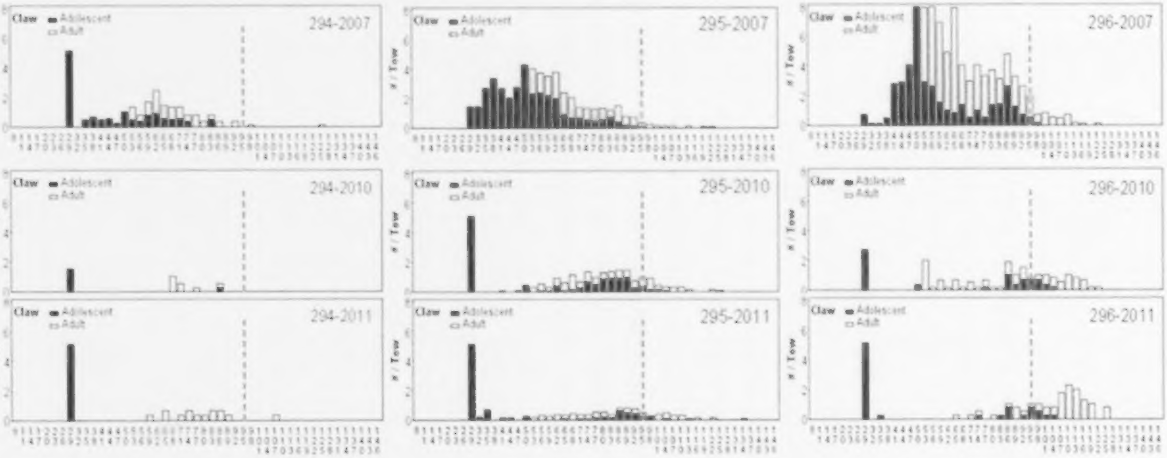


Figure 242: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from the DFO trawl survey in Fortune Bay from 2007 to 2011. The vertical dashed line indicates the minimum legal size. No survey was conducted in 2008 and 2009 is omitted due to poor trawl performance.

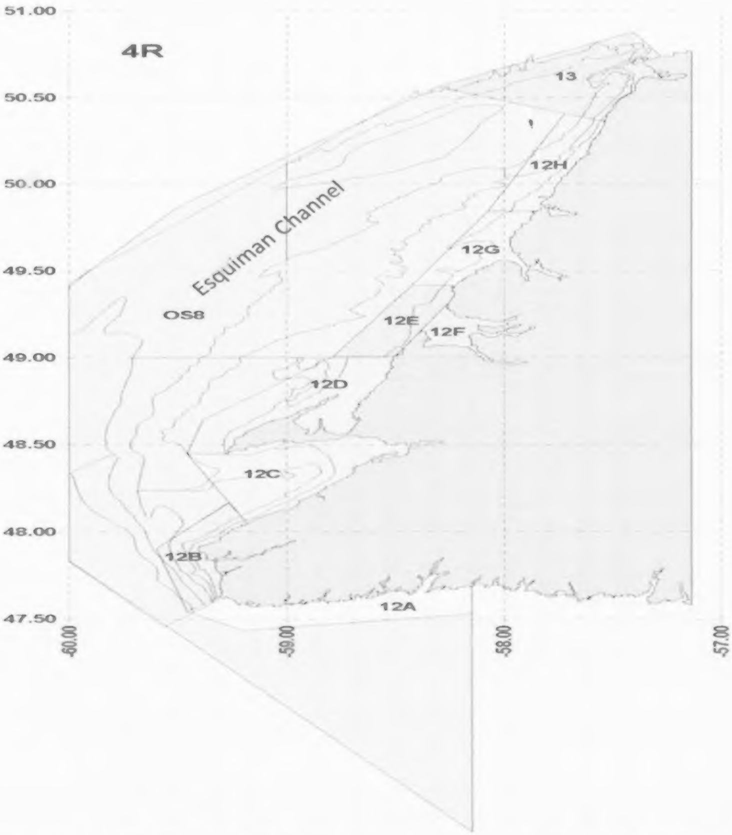

4R
13
12H
Esquiman Channel
12G
OS8
12E
12F
12D
12C
12B
12A
51.00
50.50
50.00
49.50
49.00
48.50
48.00
47.50
-60.00
-59.00
-58.00
-57.00

Figure 243: Map of Div. 4R showing Crab Management Areas (CMA) and important bathymetric features.

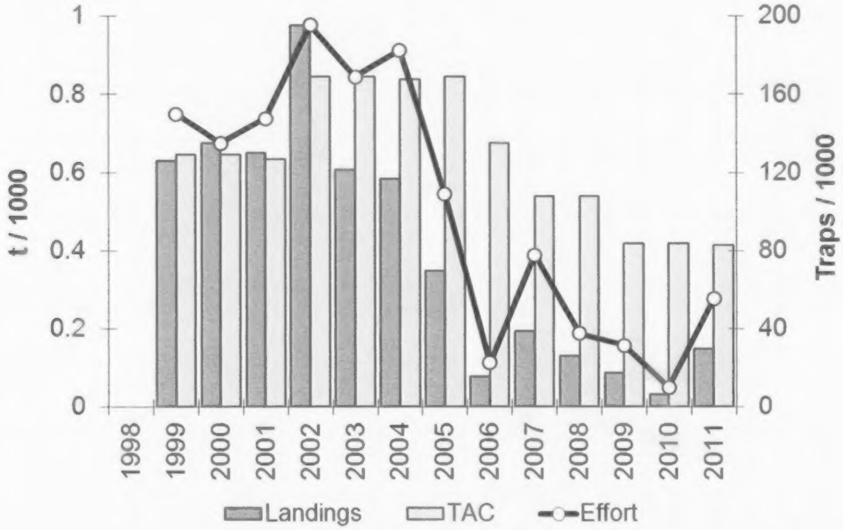


Figure 244: Trends in Div. 4R offshore landings, total allowable catch (TAC), and fishing effort.

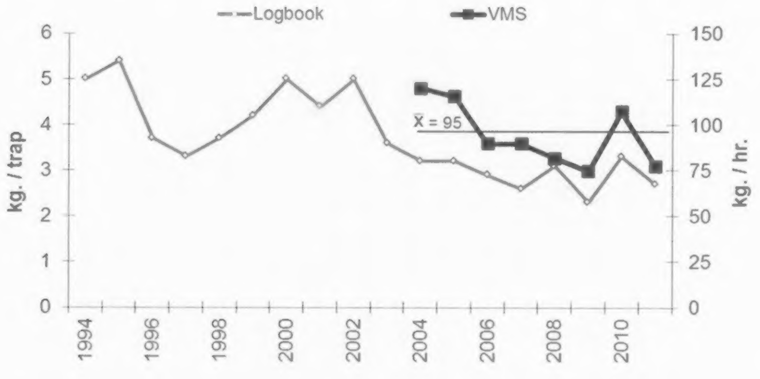


Figure 245: Trends in commercial logbook-based and VMS-based catch per unit effort (CPUE) in the Div. 4R offshore fishery. Solid black line denotes long-term VMS average.

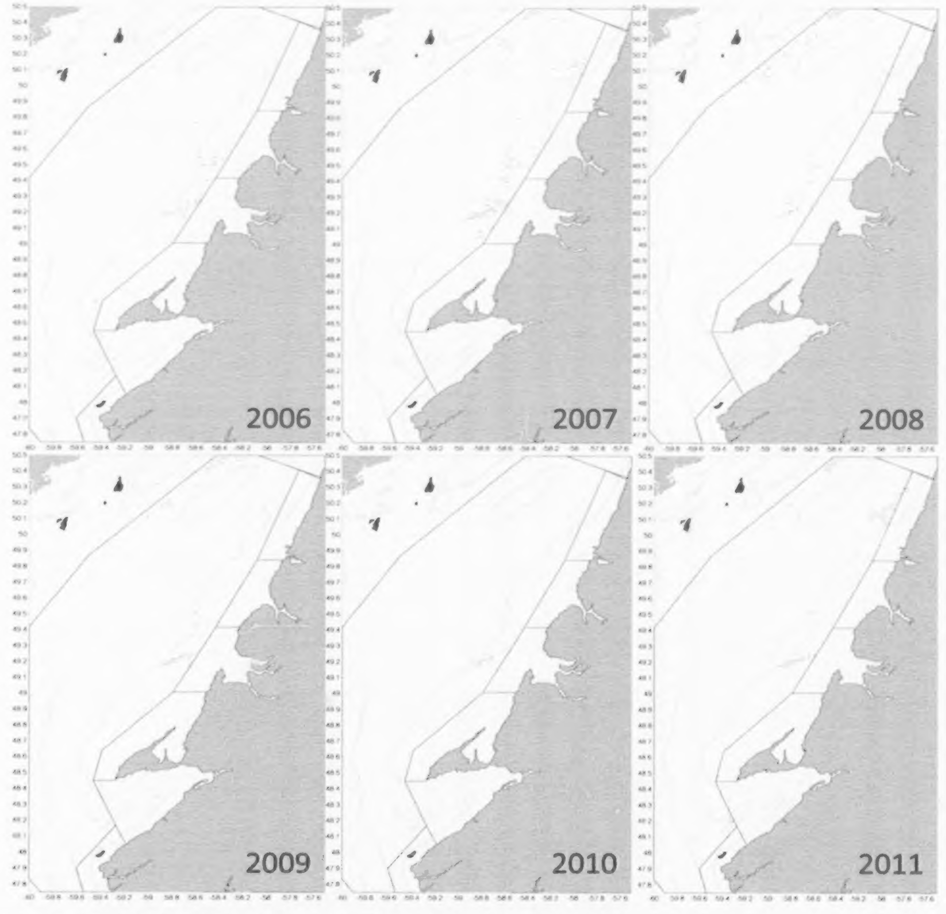

2006
2007
2008
2009
2010
2011

Figure 246: Spatial distribution of Div. 4R fishing effort by year.

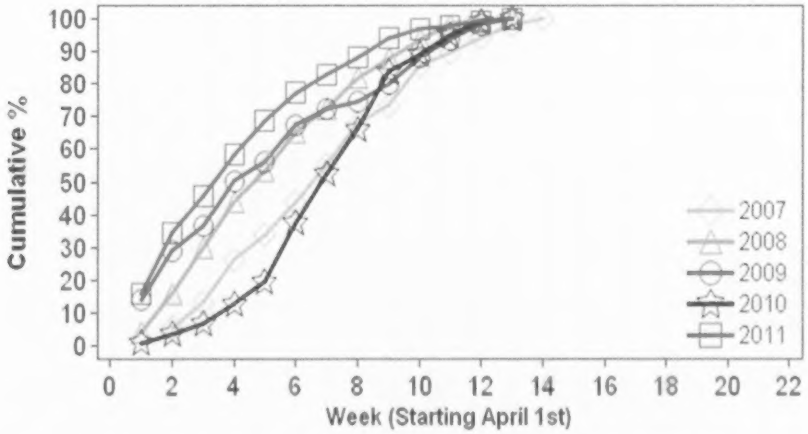


Figure 247: Seasonal trends in weekly fishing effort for Div. 4R during 2007-2011.

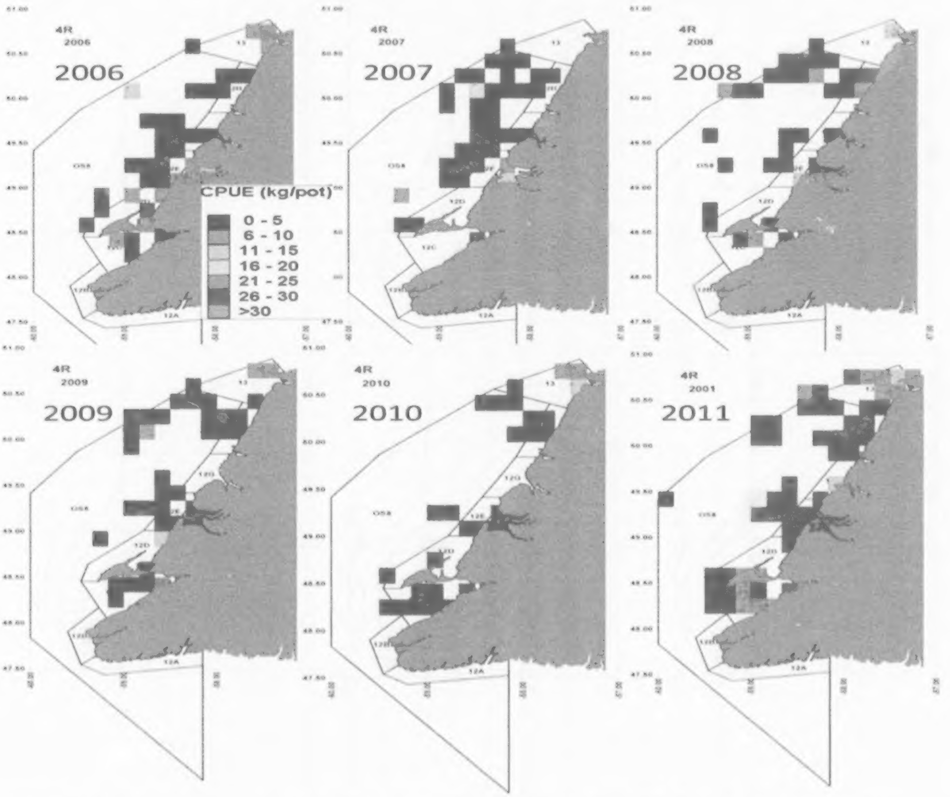

4R
2006
2006
2007
2008
2009
2010
2011
CPUE (kg/pot)
0 - 5
6 - 10
11 - 15
16 - 20
21 - 25
26 - 30
>30

Figure 248: Spatial distribution of Div. 4R logbook catch per unit effort (CPUE) by year.

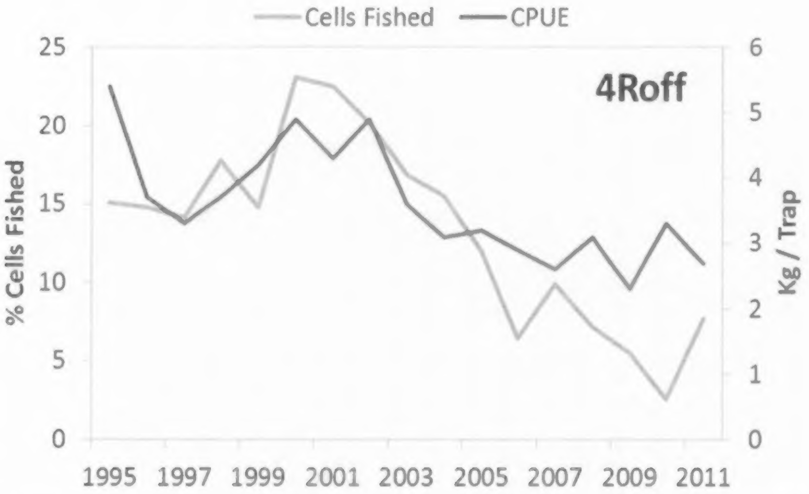


Figure 249: Trends in Div. 4R offshore commercial catch per unit effort (CPUE) vs. the percentage of 5' x 5' cells fished.

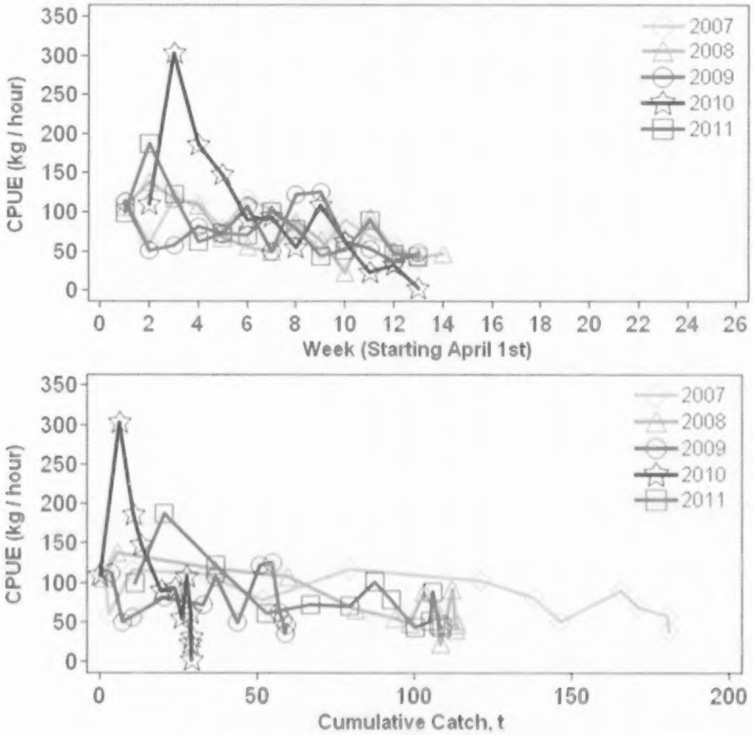


Figure 250: Seasonal trends in VMS-based catch per unit effort (CPUE) for Div. 4R offshore during 2007-2011; by week (above), and in relation to cumulative catch (below).

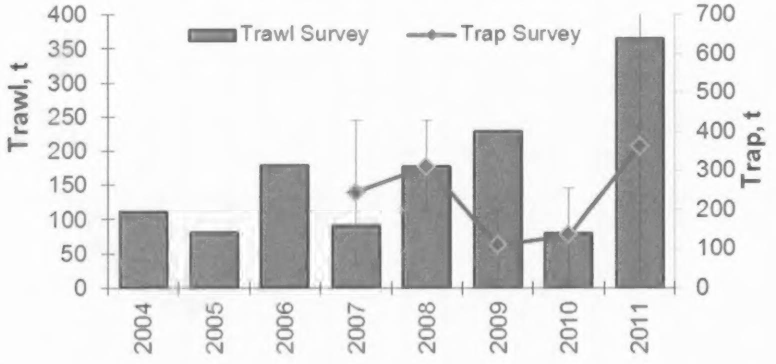


Figure 251: Trends in Div. 4R offshore summer trawl survey exploitable biomass index and the Collaborative Post-Season (CPS) trap survey biomass index.

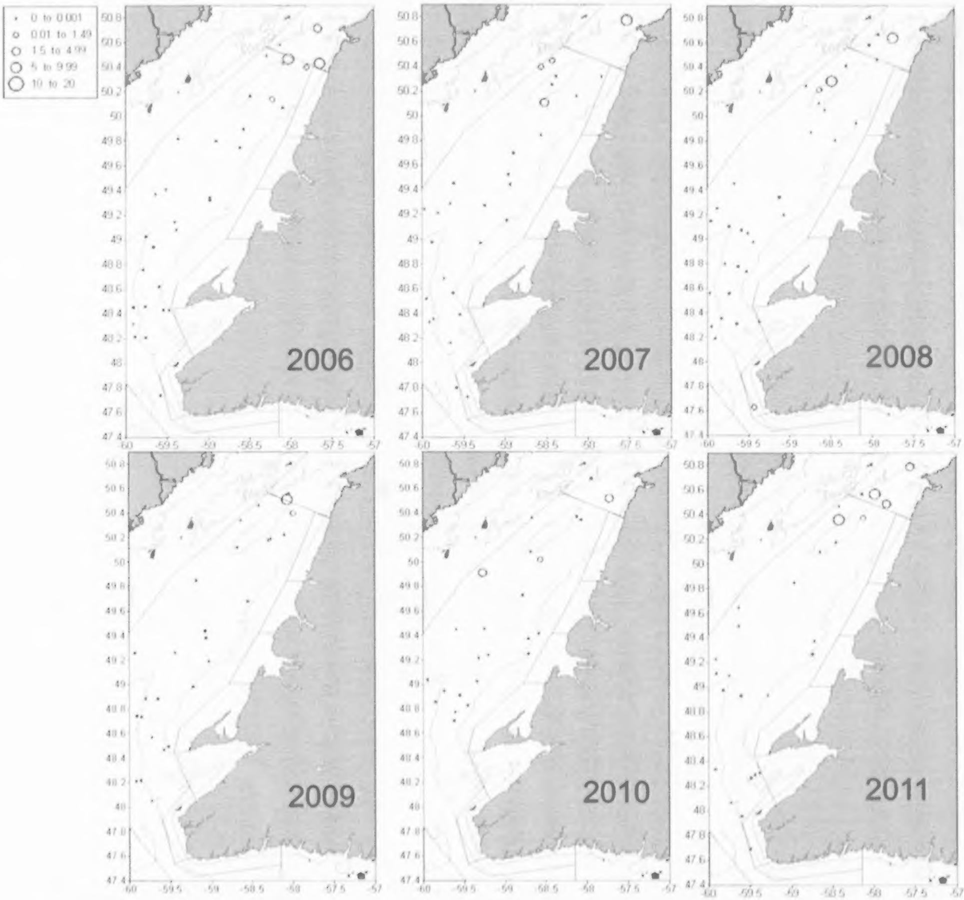

0 to 0.001
0.01 to 1.49
1.5 to 4.99
5 to 9.99
10 to 20
2006
2007
2008
2009
2010
2011

Figure 252: Spatial distribution of catches (number/set) of exploitable crab in the Div. 4R summer trawl survey.

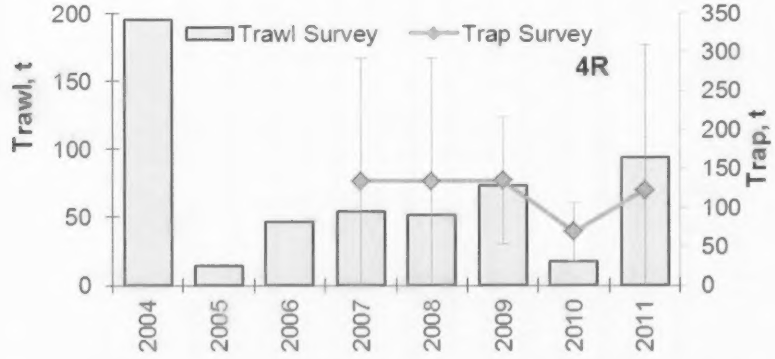


Figure 253: Trends in Div. 4R offshore summer trawl survey pre-recruit biomass index and the Collaborative Post-Season (CPS) trap survey biomass index.

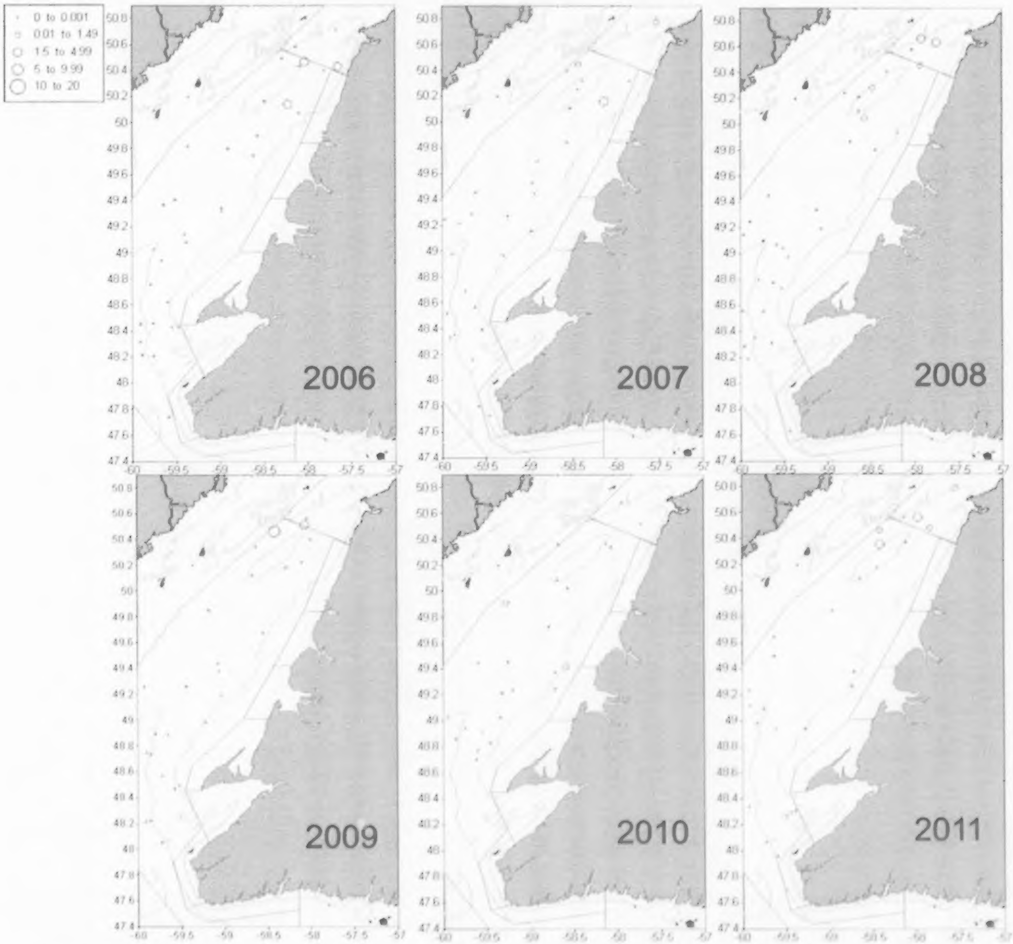

0 to 0.001
0.01 to 1.49
1.5 to 4.99
5 to 9.99
10 to 20
2006
2007
2008
2009
2010
2011

Figure 254: Spatial distribution of catches (number/set) of exploitable crab in the Div. 4R summer trawl survey.

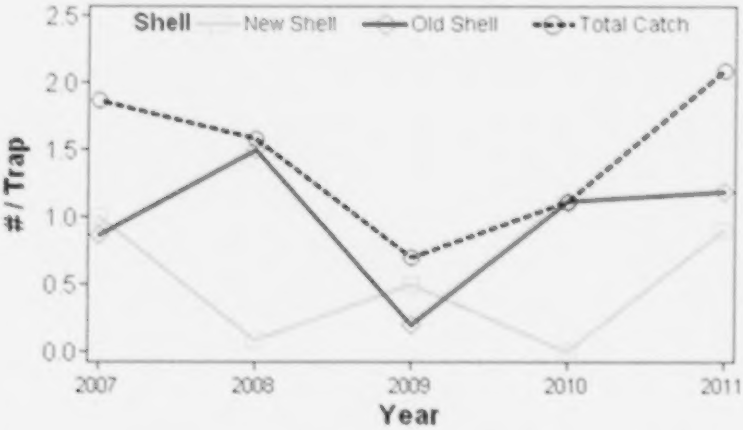


Figure 255: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Div. 4R offshore Collaborative Post-Season (CPS) trap survey.

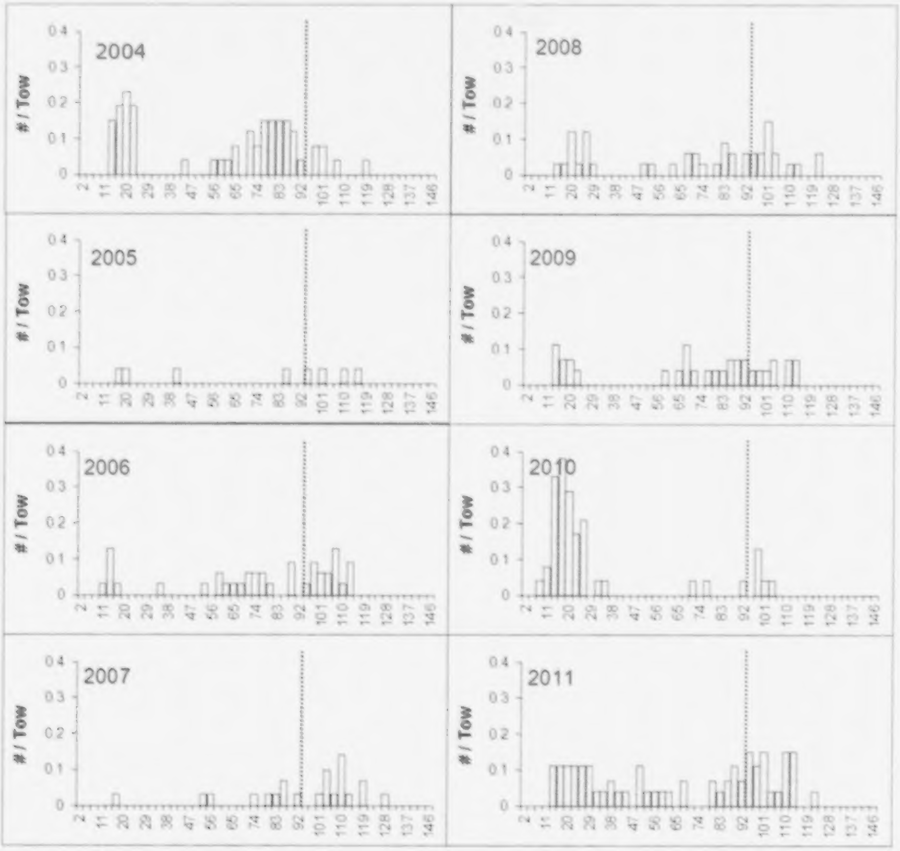


Figure 256: Trends in male carapace width distributions from the summer trawl survey in Div. 4R offshore. The vertical dashed line indicates the minimum legal-size.

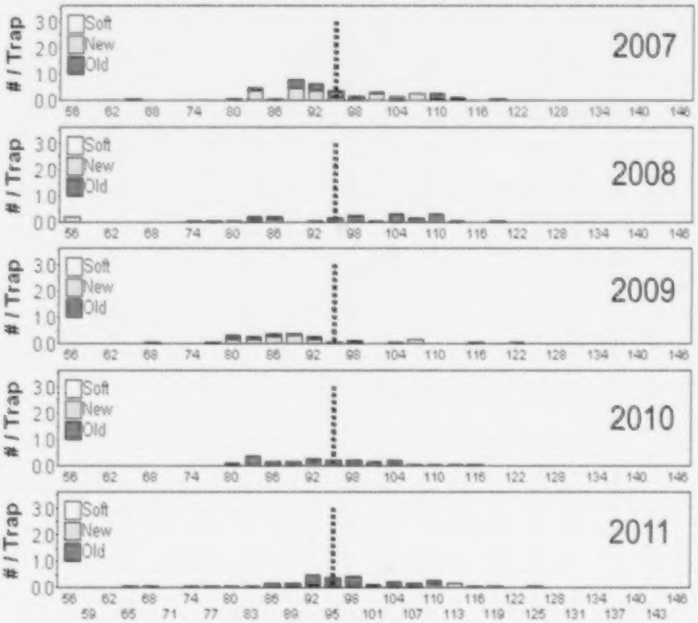


Figure 257: Trends in male carapace width distributions from core stations in the Div. 4R offshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

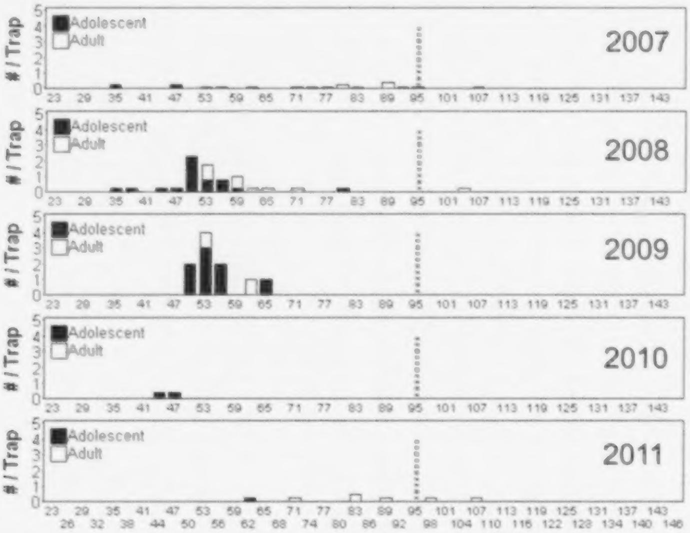


Figure 258: Trends in male carapace width distributions from small-mesh traps in the Div. 4R offshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

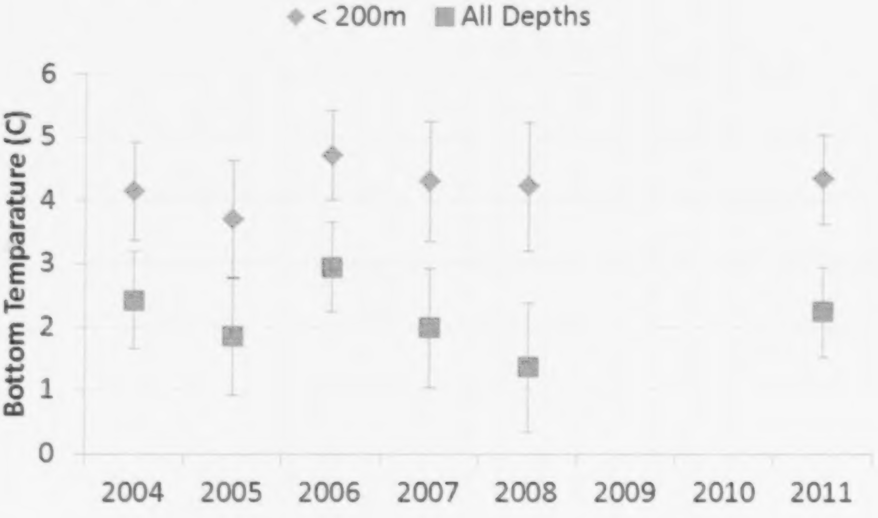


Figure 259: Trends in bottom temperature from the Div. 4R summer trawl surveys.

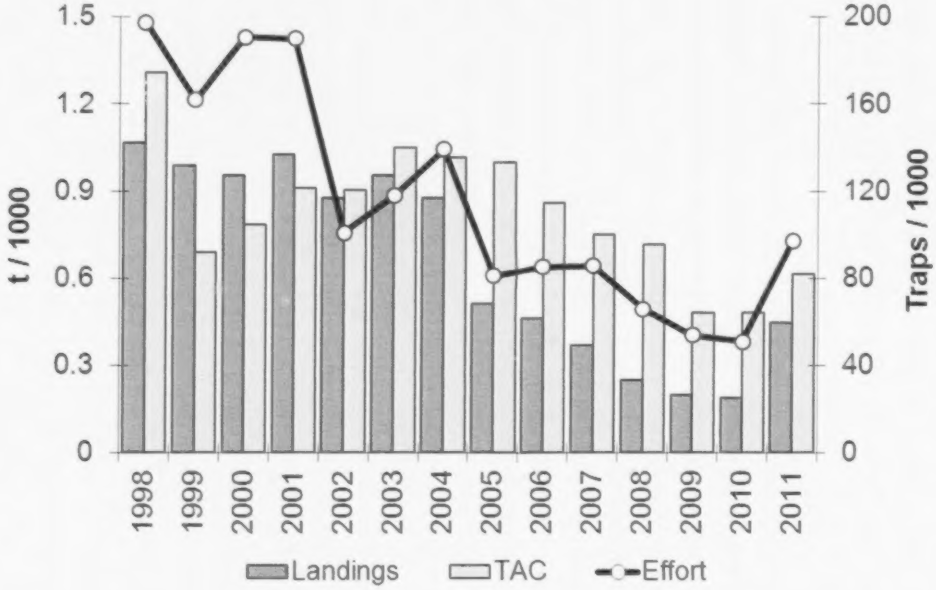


Figure 260: Trends in Div. 4R inshore landings, total allowable catch (TAC), and fishing effort.

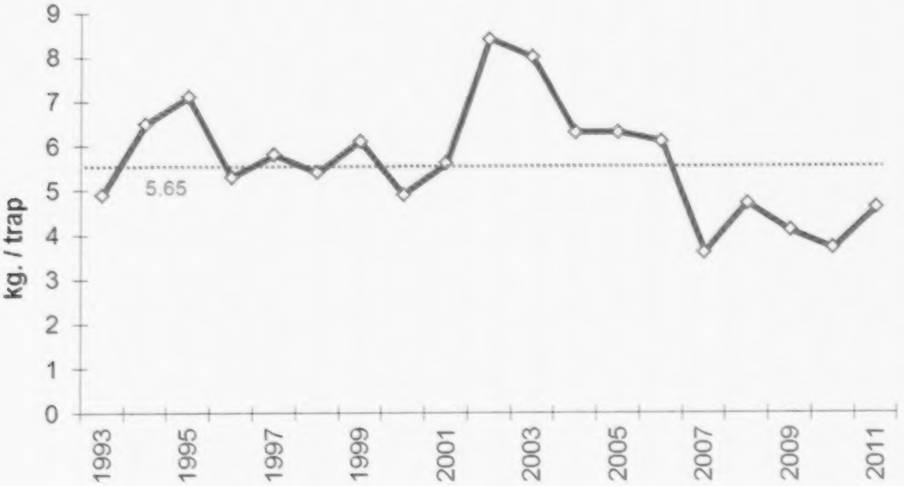


Figure 261: Trends in commercial logbook catch per unit effort (CPUE) in the Div. 4R inshore fishery.

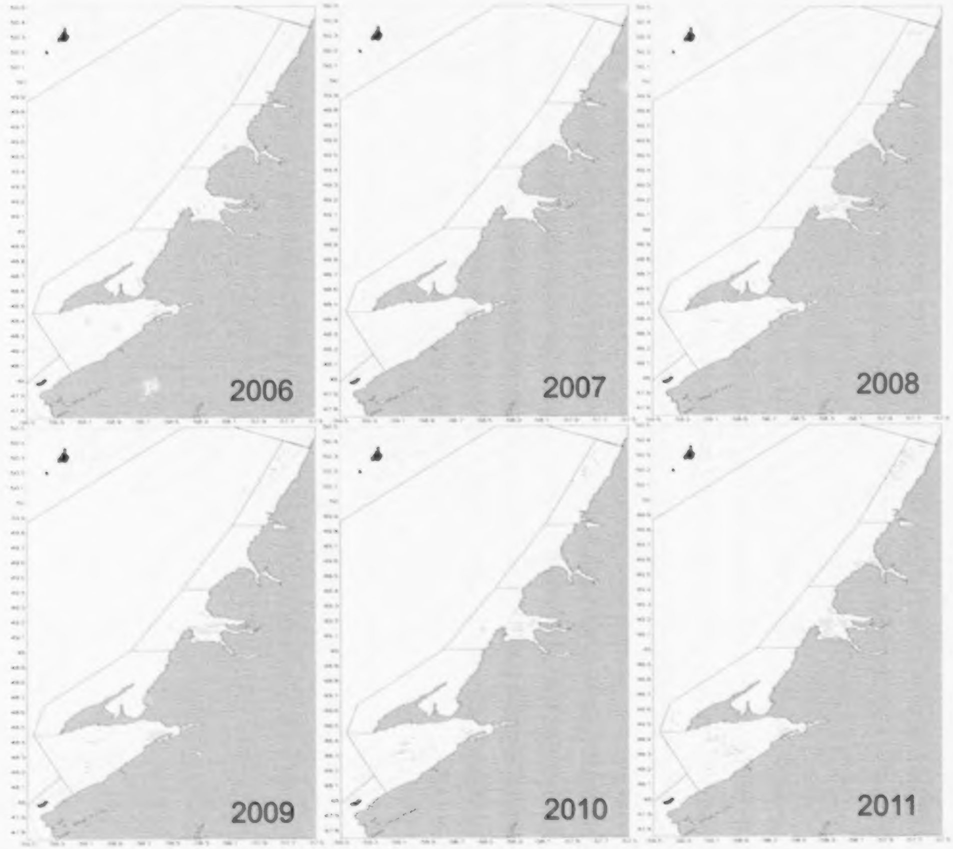

2006
2007
2008
2009
2010
2011

Figure 262: Spatial distribution of the Div. 4R inshore fishing effort by year.

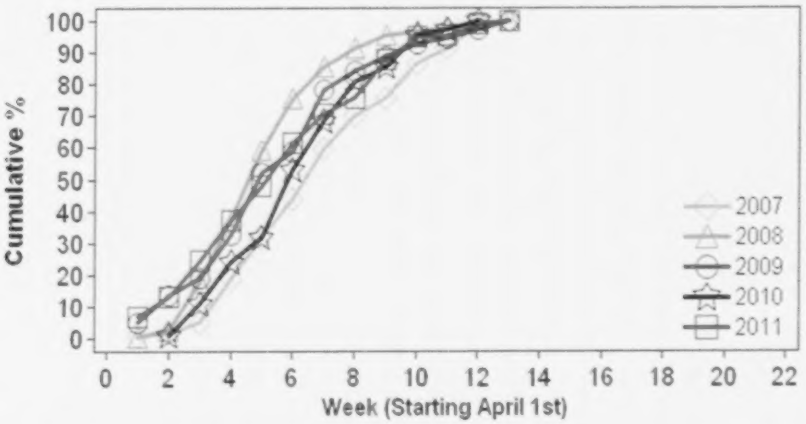


Figure 263: Seasonal trends in weekly fishing effort for Div. 4R inshore during 2007-2011.

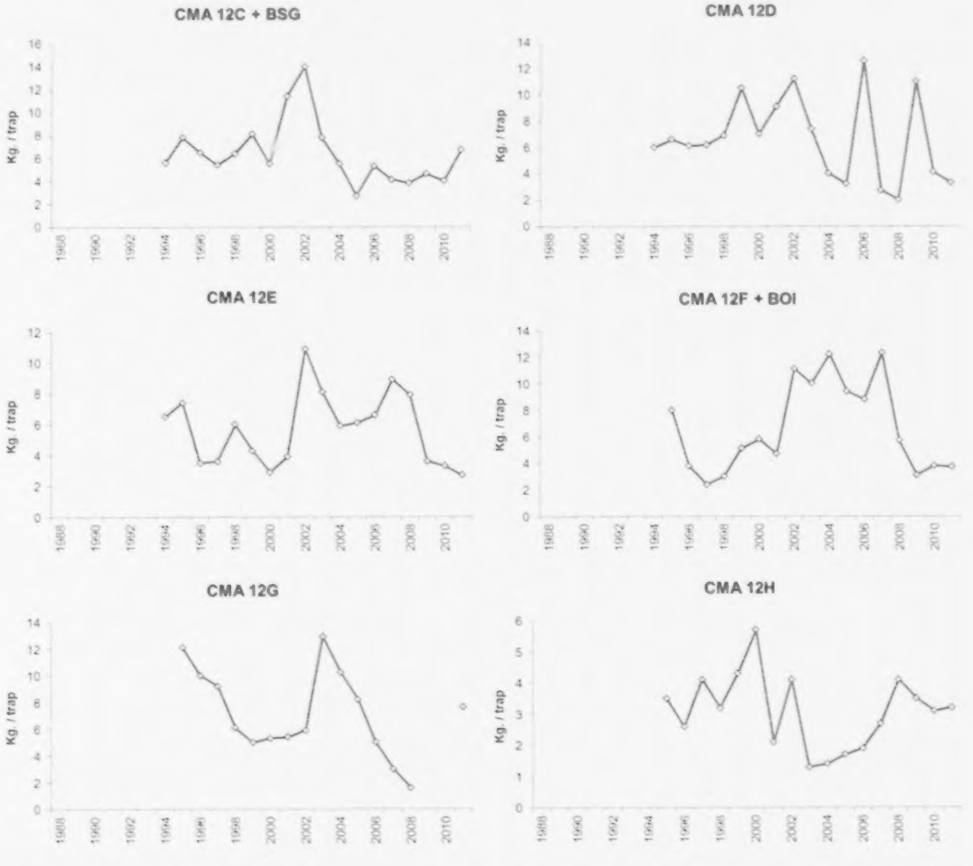


Figure 264: Trends in Div. 4R inshore logbook catch per unit effort (CPUE) by Crab Management Area (CMA).

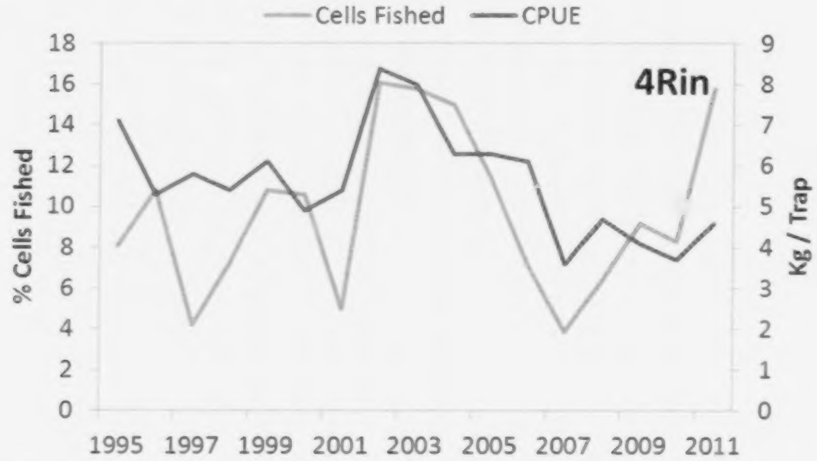


Figure 265: Trends in Div. 4R inshore logbook catch per unit effort (CPUE) vs. the percentage of 5' x 5' cells fished.

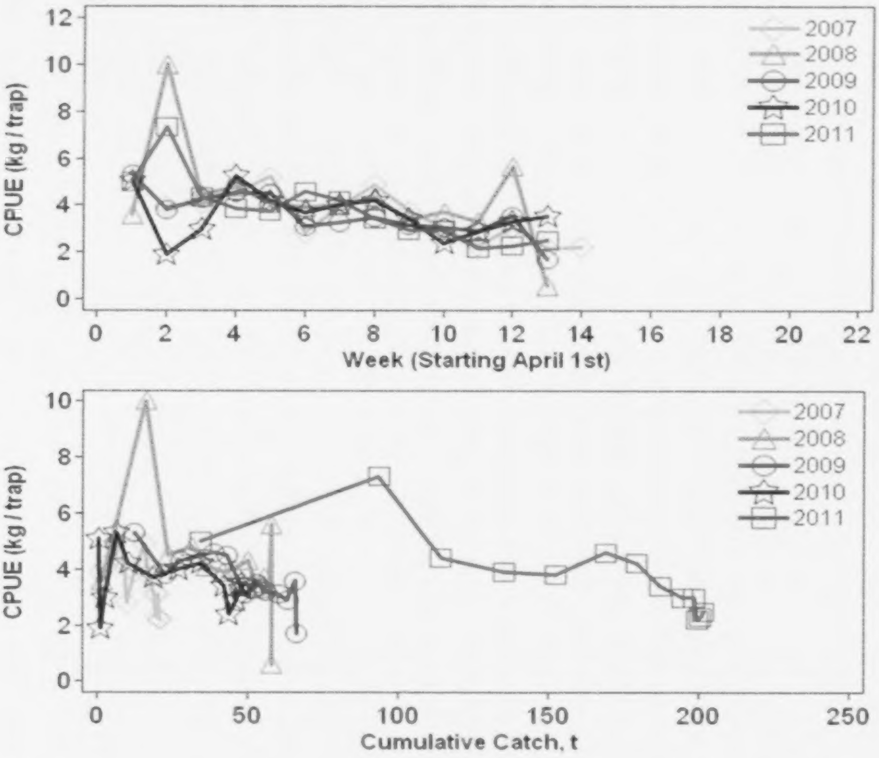


Figure 266: Seasonal trends in logbook-based catch per unit effort (CPUE) for Div. 4R inshore during 2007-2011; by week (above), and in relation to cumulative catch (below).

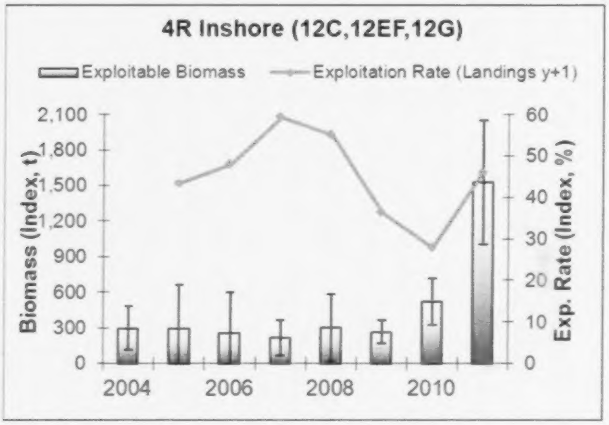


Figure 267: Exploitable biomass and exploitation rate indices from the Collaborative Post-Season (CPS) trap survey in Div. 4R inshore.

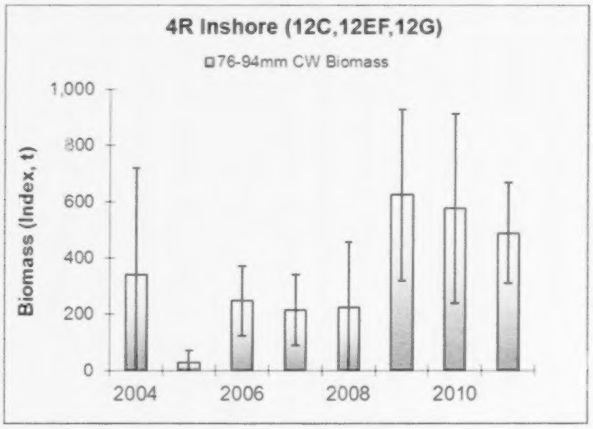


Figure 268: Pre-recruit biomass index based on the Collaborative Post-Season (CPS) trap survey in Div. 4R inshore.

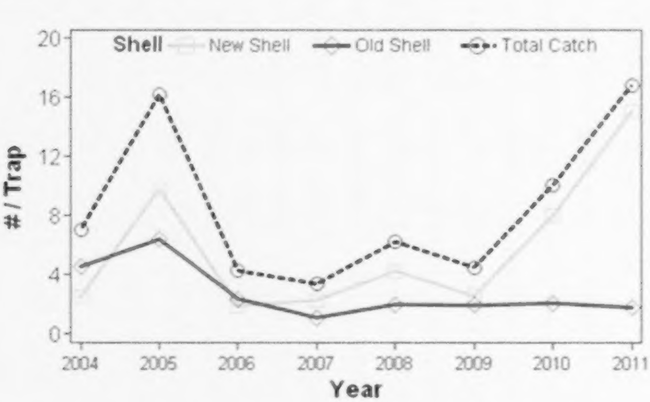


Figure 269: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Div. 4R inshore.

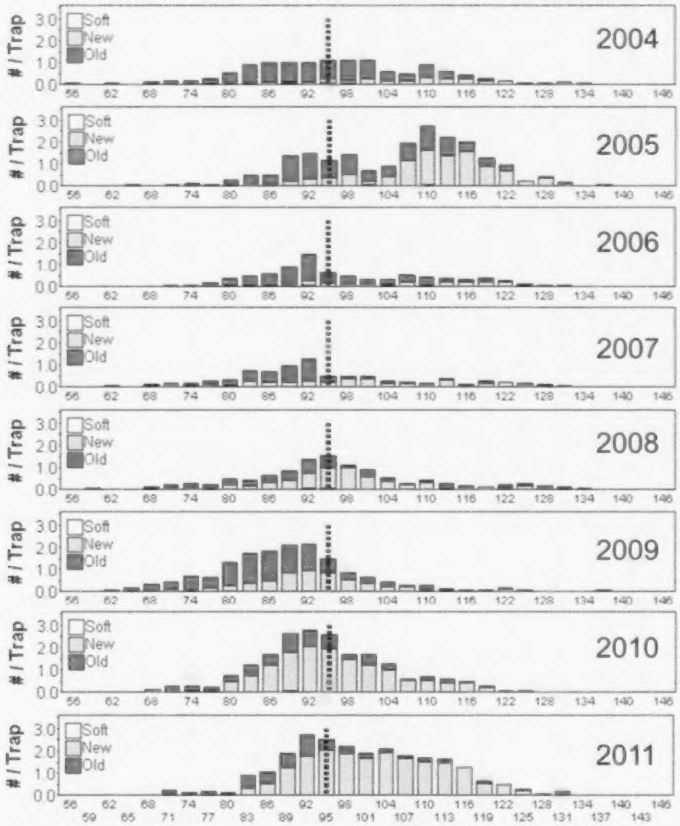


Figure 270: Trends in male carapace width distributions from core stations in the Div. 4R inshore Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

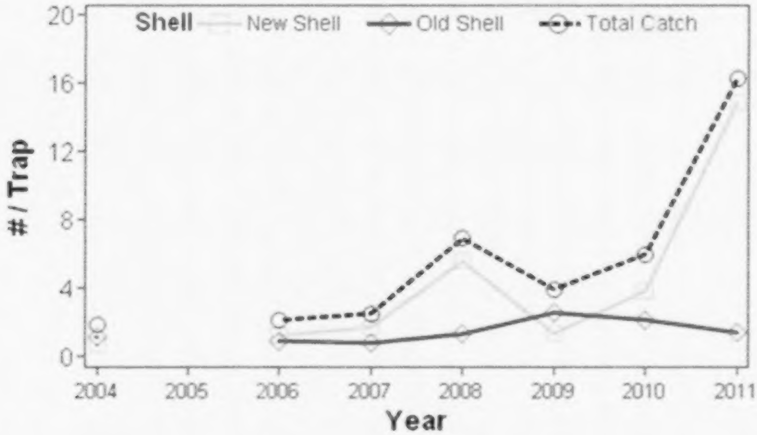


Figure 271: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 12C.

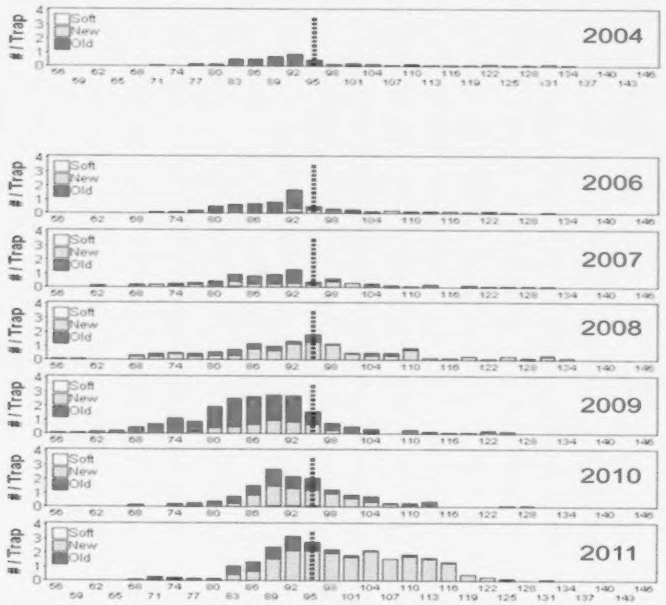


Figure 272: Trends in male carapace width distributions from core stations in the Crab Management Area (CMA) 12C from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

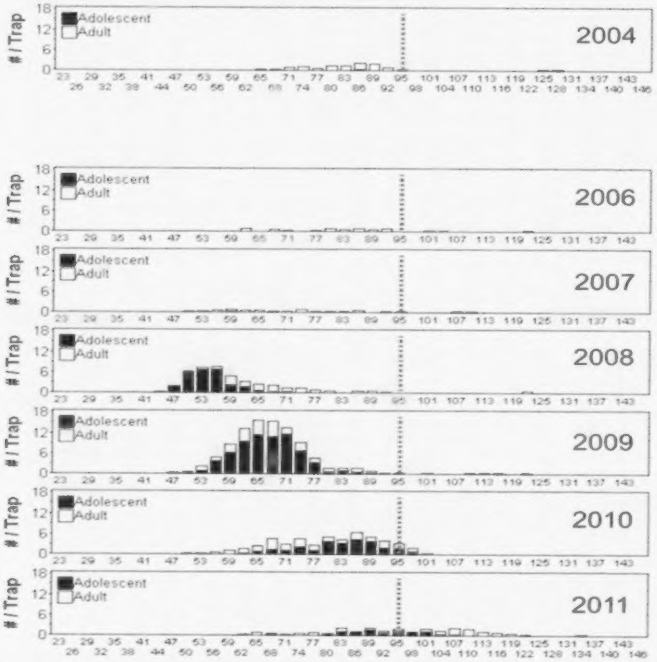


Figure 273: Trends in male carapace width distributions from small-mesh traps in Crab Management Area (CMA) 12C from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

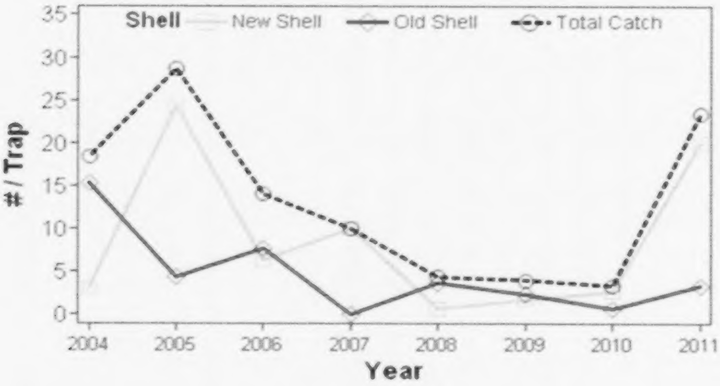


Figure 274: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 12E.

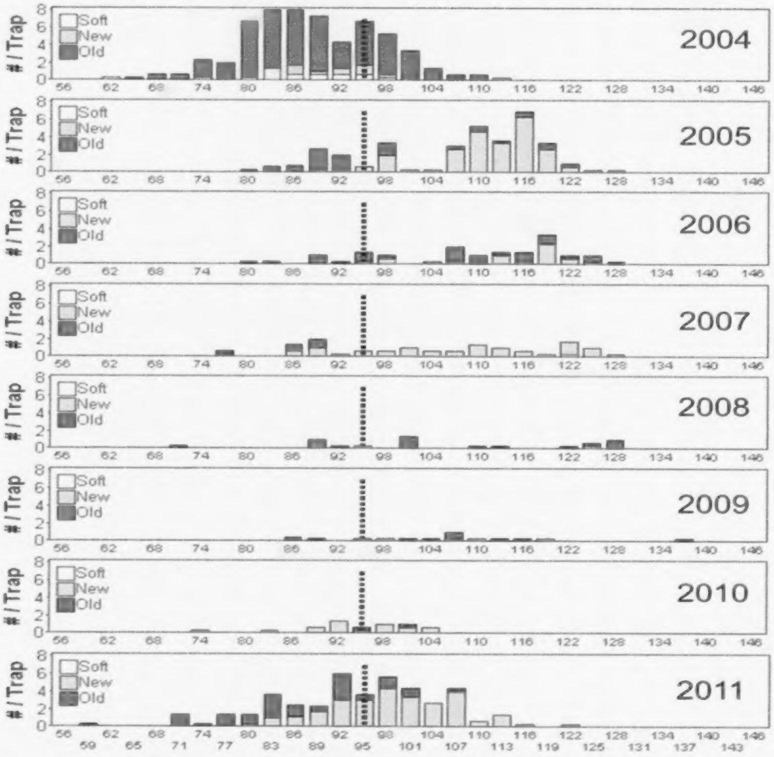


Figure 275: Trends in male carapace width distributions from core stations in the Crab Management Area (CMA) 12E from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

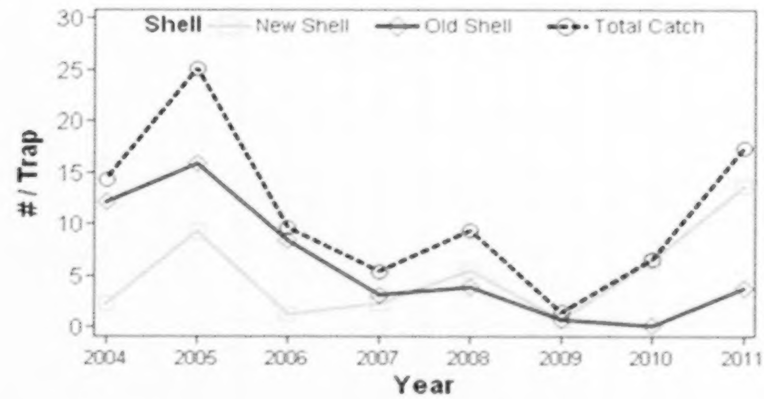


Figure 276: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 12F.

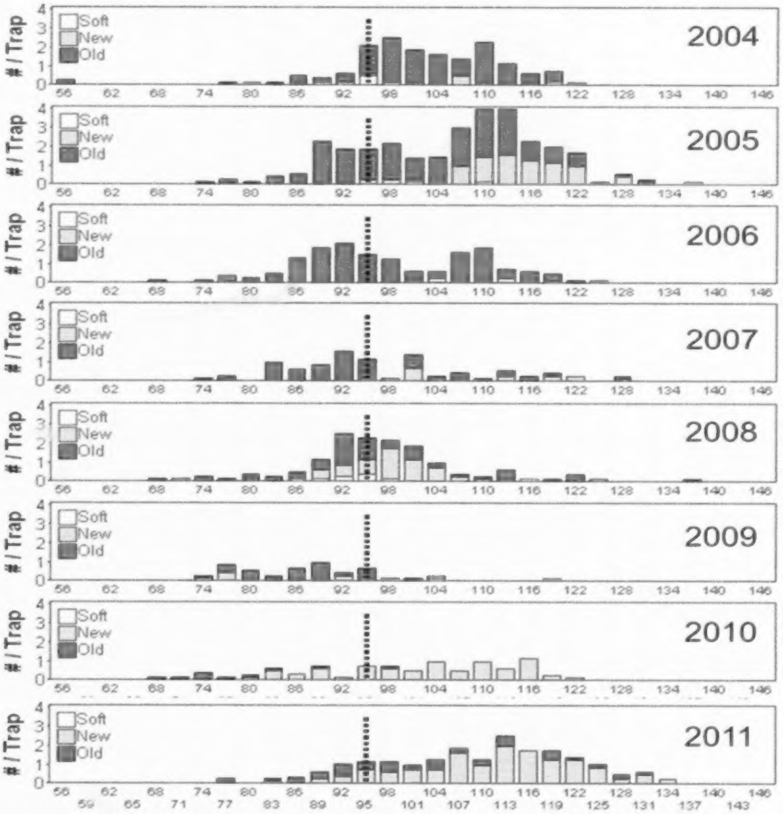


Figure 277: Trends in male carapace width distributions from core stations in the Crab Management Area (CMA) 12F from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

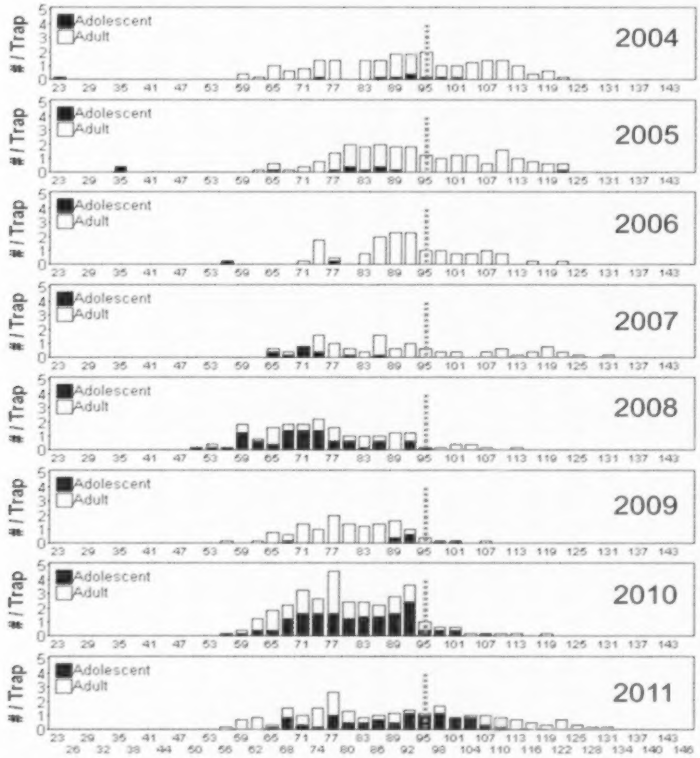


Figure 278: Trends in male carapace width distributions from small-mesh traps in Crab Management Area (CMA) 12F from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

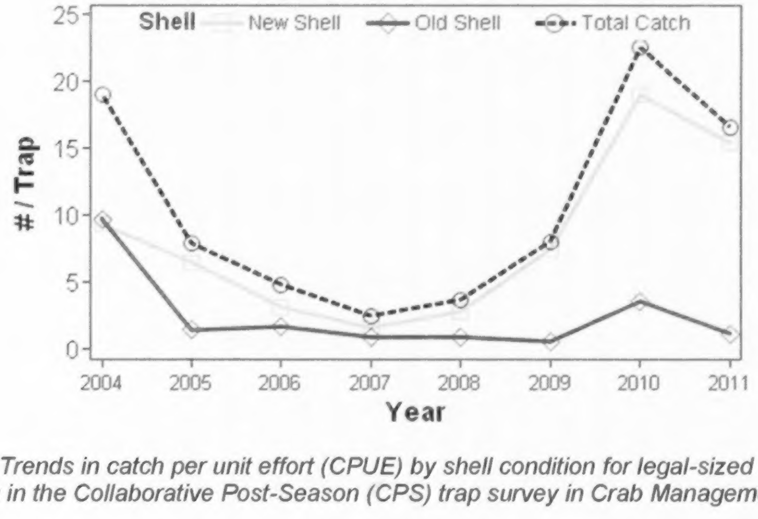


Figure 279: Trends in catch per unit effort (CPUE) by shell condition for legal-sized crabs from core stations in the Collaborative Post-Season (CPS) trap survey in Crab Management Area (CMA) 12G.

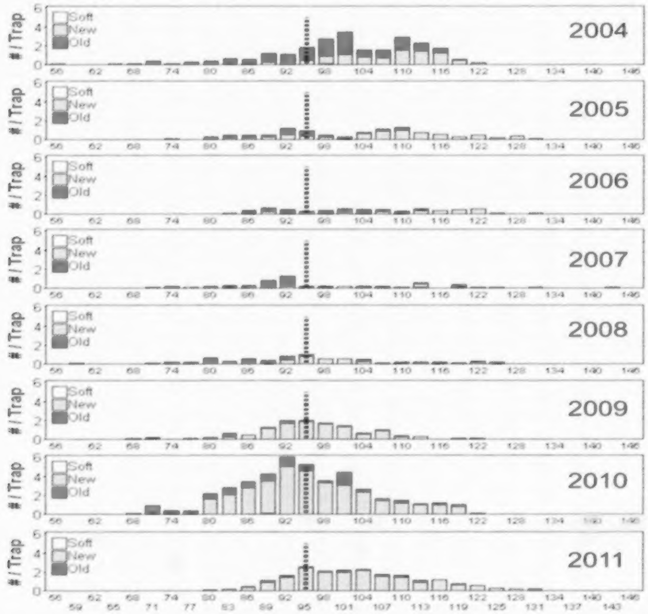


Figure 280: Trends in male carapace width distributions from core stations in the Crab Management Area (CMA) 12G from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.

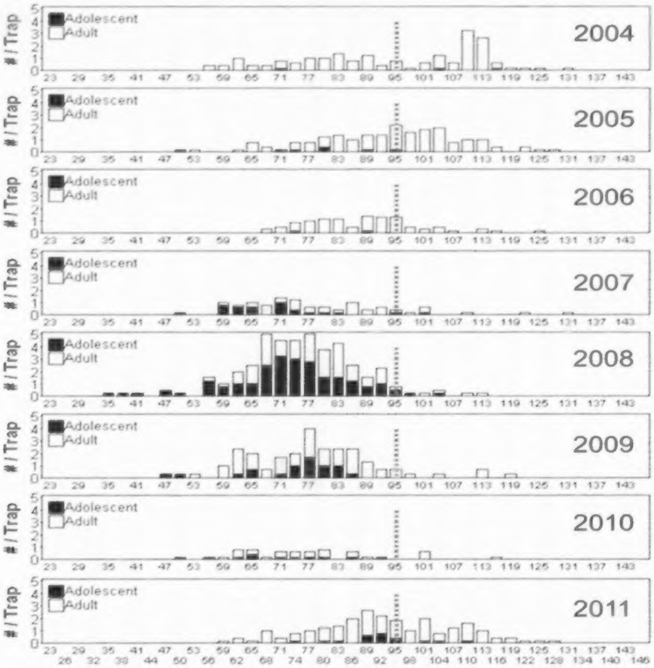


Figure 281: Trends in male carapace width distributions from small-mesh traps in Crab Management Area (CMA) 12G from the Collaborative Post-Season (CPS) trap survey. The vertical dashed line indicates the minimum legal size.